JAN 21 1944

Heating Piping & Air Conditioning

DESIGN
INSTALLATION
OPERATION
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INDUSTRIAL
COMMERCIAL
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BUILDINGS

39: Journal Section of the American Society of Heating and Ventilating Engineers

JANUARY 1944 DIRECTORY NUMBER

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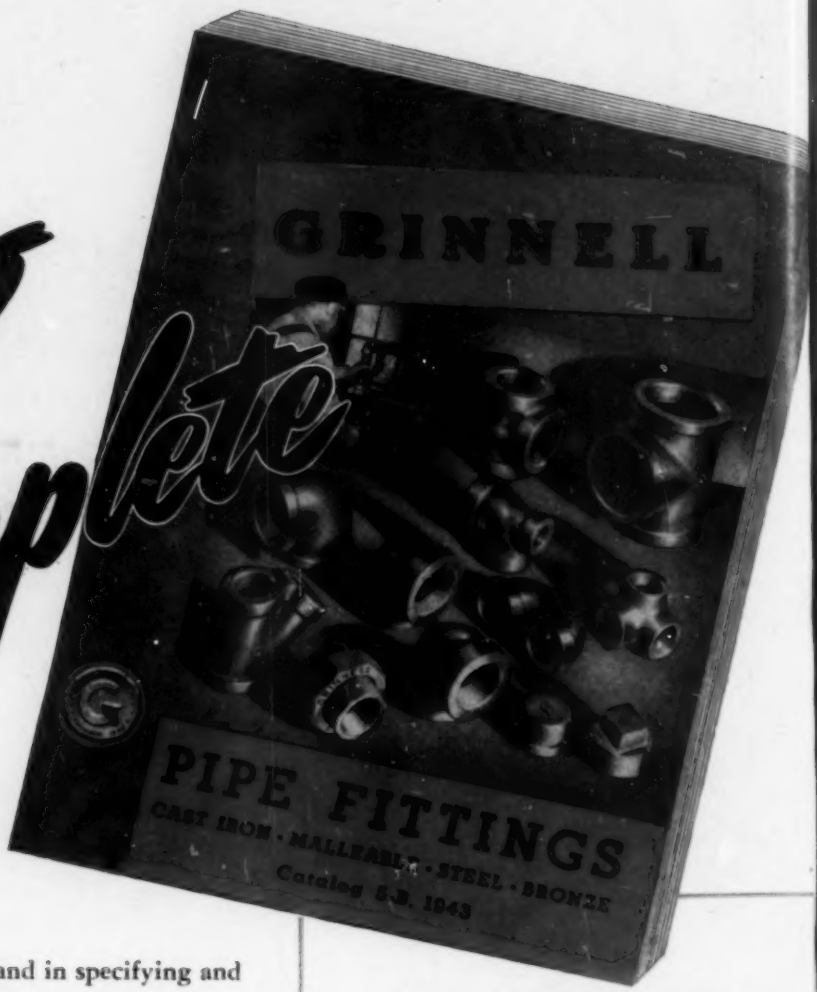

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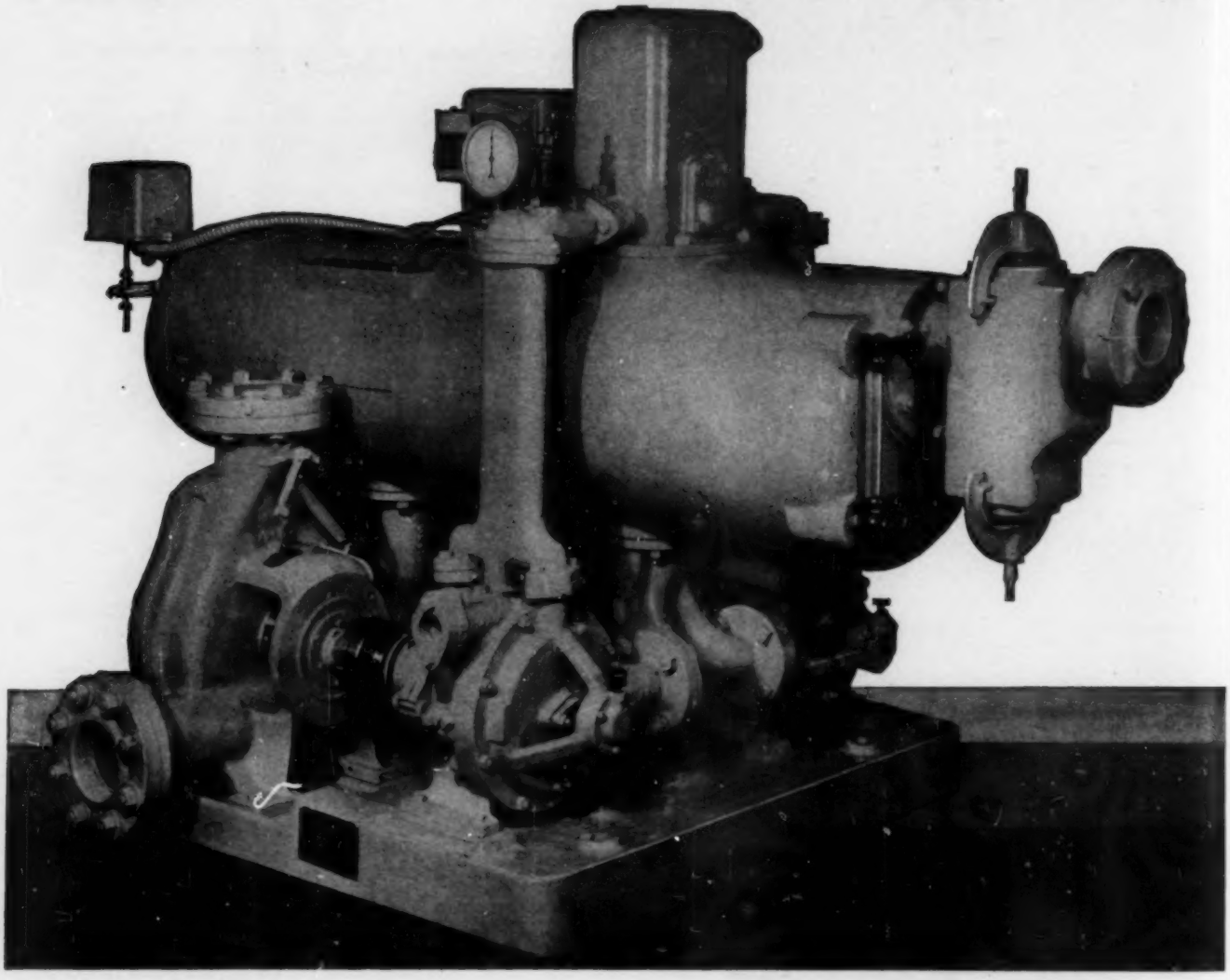
Where Heat Must Not Fail—Install this SAFE Heating Pump!



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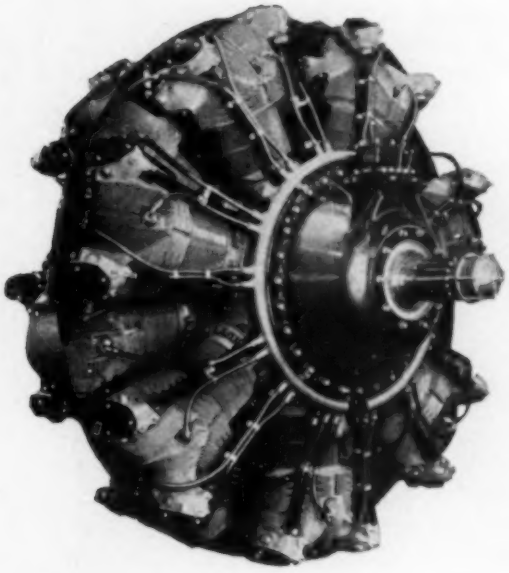


Rated at 1700 hp, this Wright Cyclone 14 cylinder engine is playing a major part in winning the war, as is air conditioning

Dehumidifying the Core Storage Room of Big Magnesium Foundry

INTEREST IS being focused on the place magnesium may find in our postwar economy, because of its vital role in war production and its ever-growing use during the past few years. Here is a strictly technician's metal—from the time it is taken from sea water until it ends up as part of a machine. It requires refinements in handling that make it differ from all ferrous and other nonferrous metals. Some problems are accentuated by the current press for mass production; one of these is the need for special handling of cores to prevent pickup of moisture between manufacture and use. This requires a dehumidification or air conditioning system.

Foundry Practice

Before describing the dehumidification system installed in the core storage room of the Wright Aeronautical Corp. magnesium foundry at Lockland, Ohio, it might be of value to have a brief review of casting procedure. Everyone is familiar with practice in the ferrous metal field where cores are formed of sand and oil and then baked at a temperature high enough to make them sufficiently strong for handling. The cores are then placed in the green sand mold (without oil binder) so that when metal is poured, the volume occupied by the core becomes a cavity in the casting.

In mass production foundries, particularly of the nonferrous type, both cores and molds are subjected to considerable moving and handling. Generally, the work flow starts at the sand mixers and progresses on mechanical conveyors to assembly of cores and molds, then ultimately to pouring, shakeout, removal of gates and risers, cleaning, water test, and final inspection. Both internal and external cores are classified as cores, although the latter really form part of the mold.

Magnesium Is Different

The peculiarities of magnesium, however, add complications to this rather simple process. Magnesium readily burns at its melting point if surrounded by air. The reaction between magnesium and oxygen (in air) must be prevented during handling of the molten metal. Burning is prevented during melting by use of a borax and sulphur flux which produces an inert gas to form a protective layer over the molten metal. During the pouring process the flux is confined to the surface and tends to ride as a skim on top while the unfluxed metal flows into the gates and risers. Similar fluxing material is used in unbaked molds for the same purpose.

Magnesium—a metal which is expected to play a vital role in our postwar economy because of the job it is already doing in war production—presents unique problems; one is the need for special handling of cores in foundries to prevent moisture pickup. This problem is solved by the air conditioning engineer by applying the same dehumidification techniques and equipment used in other process and comfort air conditioning installations . . . At the Wright Aeronautical Corp. plant, a combination of well water precooling, direct expansion refrigeration, and silica gel dehydration is used to maintain the necessary low relative humidity and proper temperature conditions for core making and storage. Realto E. Cherne, Cincinnati branch manager of Carrier Corp., and Charles G. Murphy, Wright foundry engineer, explain how the system was calculated, its operating cycle, and its control.

Core Making

Use is made in this foundry of core blowing machines operated by women. These machines force a measured charge of processed sand into the core mold at 90 psi air pressure. The product is then placed on a conveyor which extends through a bake oven held at 450 F. After baking, the cores are subjected to a spray treatment peculiar to magnesium casting. A mixture consisting of ammonium silica fluoride, ammonium boro fluoride, and ammonium acid fluoride is used. These salts have the property of sublimation. Upon contact with molten magnesium in the molds, the heat of sublimation is taken from the metal, causing surface chilling, which in turn forms a protective barrier between metal and sand to prevent burning of the metal as expressed in the chemical formula $2M_g + O_2 \rightarrow 2M_gO + \text{Heat}$.

Returning to the production process, the sprayed cores are next conveyed through a spray dry oven. From there they are conveyed to inspection and then to storage.

Larger Molds

Floor molds are not chemically sprayed because they are not baked and, consequently, can be dusted with borax-sulphur flux, as previously stated (this flux, if subjected to baking temperature, would break down to form SO_2).

Moisture a Trouble-Maker

Should cores be allowed to absorb moisture before being put to use, the following reaction would take place when pouring: $M_g + H_2O \rightarrow M_gO + H_2\uparrow$. The hydrogen gas would promote burning of the metal. This, of course, would result in rejected castings and the penalty would be severe as the rejection would take place after all foundry operations prior to rough inspection (as distinguished from inspection after machining has been done). This demonstrates the need for storing the cores in a dry atmosphere.

Core Storage Room

When consideration is given to the tremendous engine output of this huge factory, it can be readily understood that mag-foundry core storage will require a sizable space. The room is 300 ft long by 40 ft wide by approximately 10 ft high. It has no outdoor exposure, being entirely within the foundry building. Partition walls are made of 4 in. cinder block, 1 in. insulating board, and 7 in. tile. The ceiling is ¾ in. cement plaster, 1 in. insulating board, and 2½ in. concrete slab. A moisture barrier or vapor seal is applied to both sides of the insulation board. The floor is concrete on the ground. Access to the room is gained by six double 7 ft by 5 ft doors. The ceiling slab is sufficiently reinforced to provide equipment space above. All air handling and refrigeration equipment for this installation is installed on the mezzanine level thus formed. The remaining space is used for additional mechanical equipment and storage.

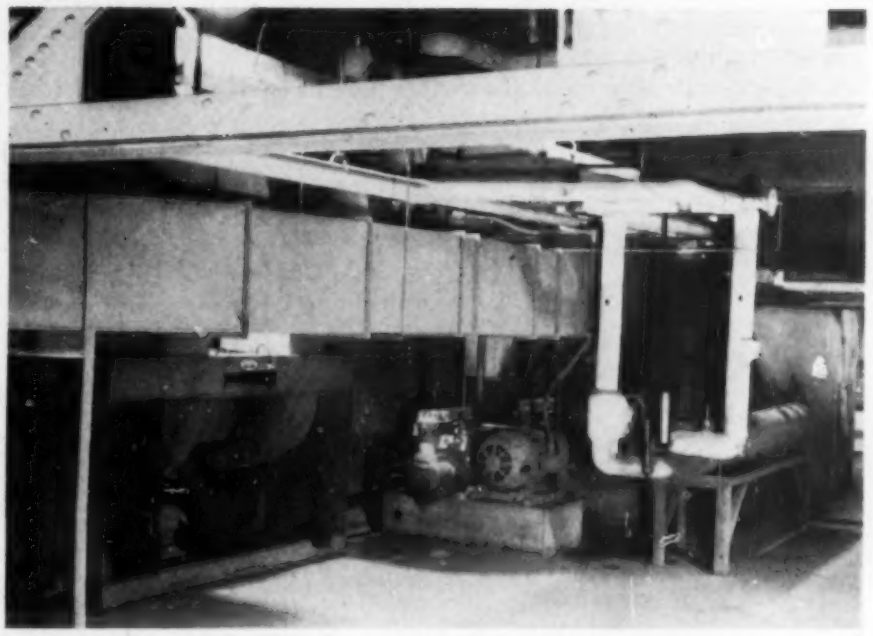
The art of core making reaches a high point in the production of such complex cores as this one, with many thin wall sections and complicated forms

The Dehumidification System

Design Conditions

Summer outside design conditions for the plant location are normally taken as 95 F dry bulb and 78 F wet bulb (48 per cent relative humidity, 71.7 F dew point, 117.3 grains per lb). For a system which uses a washer or coils for accomplishing both cooling and dehumidification, these maximum outside conditions are usually considered as simultaneous because they represent the maximum duty the equipment will be required to perform. When independent dehumidification equipment is utilized—as in this system—consideration must be given to possible higher outdoor air moisture content at the same 78 F wet bulb temperature. Latent heat gain to the space was, therefore, based on ambient conditions of 80 F dry bulb and 78 F wet bulb (92 per cent relative humidity, 77.4 F dew point, 142 grains per lb). Note that this increases the latent load about 25 per cent or, stated in another manner, requires lower dew point supply air to maintain the design room conditions.

Design room conditions are 90 F dry bulb and 10 per cent relative humidity (58 F wet bulb, 27 F dew point, 20.8 grains per lb), being a



Load on the direct expansion coils is handled by two 10 hp compressors operating on a common water cooled condenser. Precooling is by well water

compromise between economic equipment size, conditions for the men who work in the room, and product requirements. Laboratory tests were conducted to confirm the practicability of using these conditions as a basis of design.

Load Calculations

Prediction of exact loads is made difficult by two items:

1) Manufacture of the cores is a variable inasmuch as over 30 different types are required; some of these are made in accordance with overall foundry production schedules while others are made in quantities and stored until needed. Also, the temperature at which the cores enter the dehumidified room will vary considerably. It doesn't matter how many tons of cores are stored in the room, since these will not add to either the sensible or latent heat loads. Calculations were based on 5 tons of cores and 3 tons of metal per hr entering the room at 300 F.

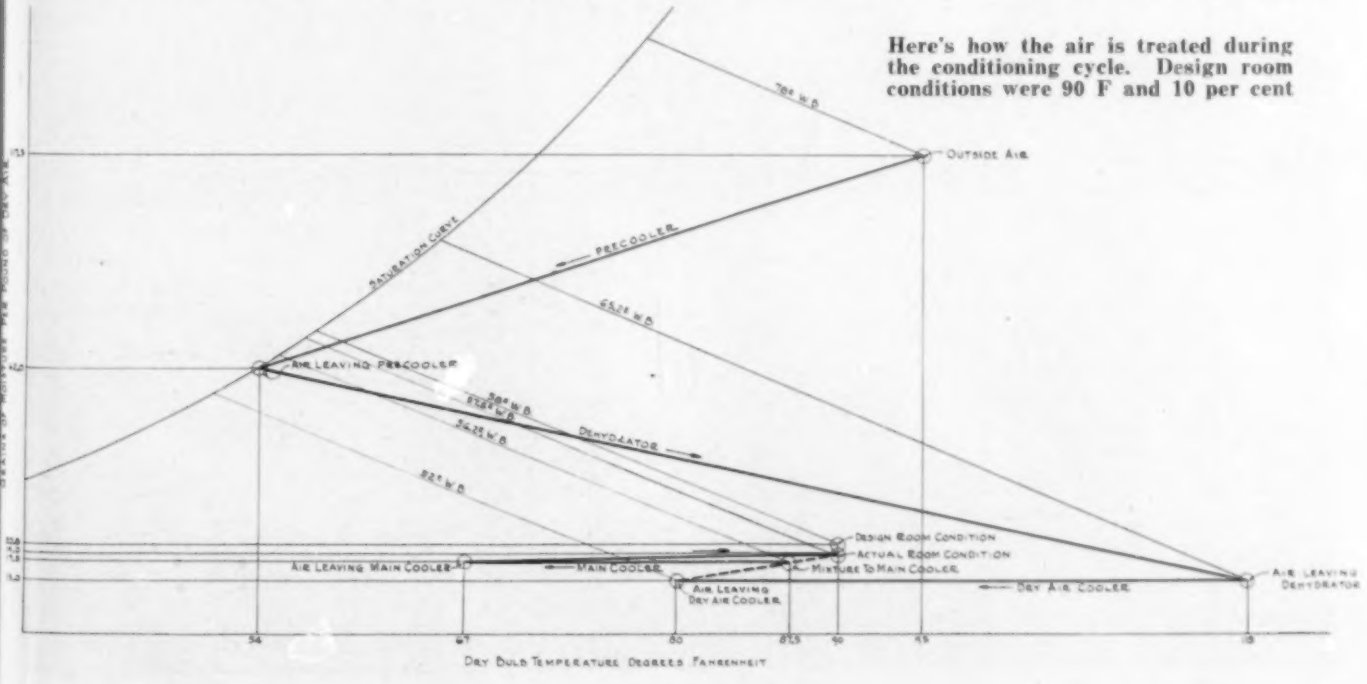
2) Door opening frequency will determine the amount of infiltration of outside moisture-laden air. This is a function of production schedules and product usage. Preliminary calculations indicated the impracticability of allowing all the doors to be open continuously as might be desired by the production men. Some consideration was given to entrance vestibules (judged a nuisance by the production men) and dry air screens at each door (involving higher installation costs). Again, a practical compromise was required: all doors are to be kept closed except when trucks are actually entering or leaving; and total exfiltration of dry air necessary to offset door infiltration was assumed as 10,000 cfm. This figure, while not exactly a guess, is admittedly an assumption.

The sensible heat gain (221,500 Btu per hr) through the walls and ceiling was calculated by the method given in the ASHVE's Heating, Ventilating, Air Conditioning Guide. The product load of approximately 778,500 Btu per hr brings the total room sensible heat gain to 1,000,000 Btu per hr. Both figures include an allowance for the heat added by the supply fans.

Moisture seepage through the walls and ceiling was calculated as equivalent to 38,700 Btu per hr. The dew point of the supply air must be lowered below 20.8 grains to allow for this latent heat gain.

Equipment Layout and Capacities

Because of the length of this storage room it was decided to use

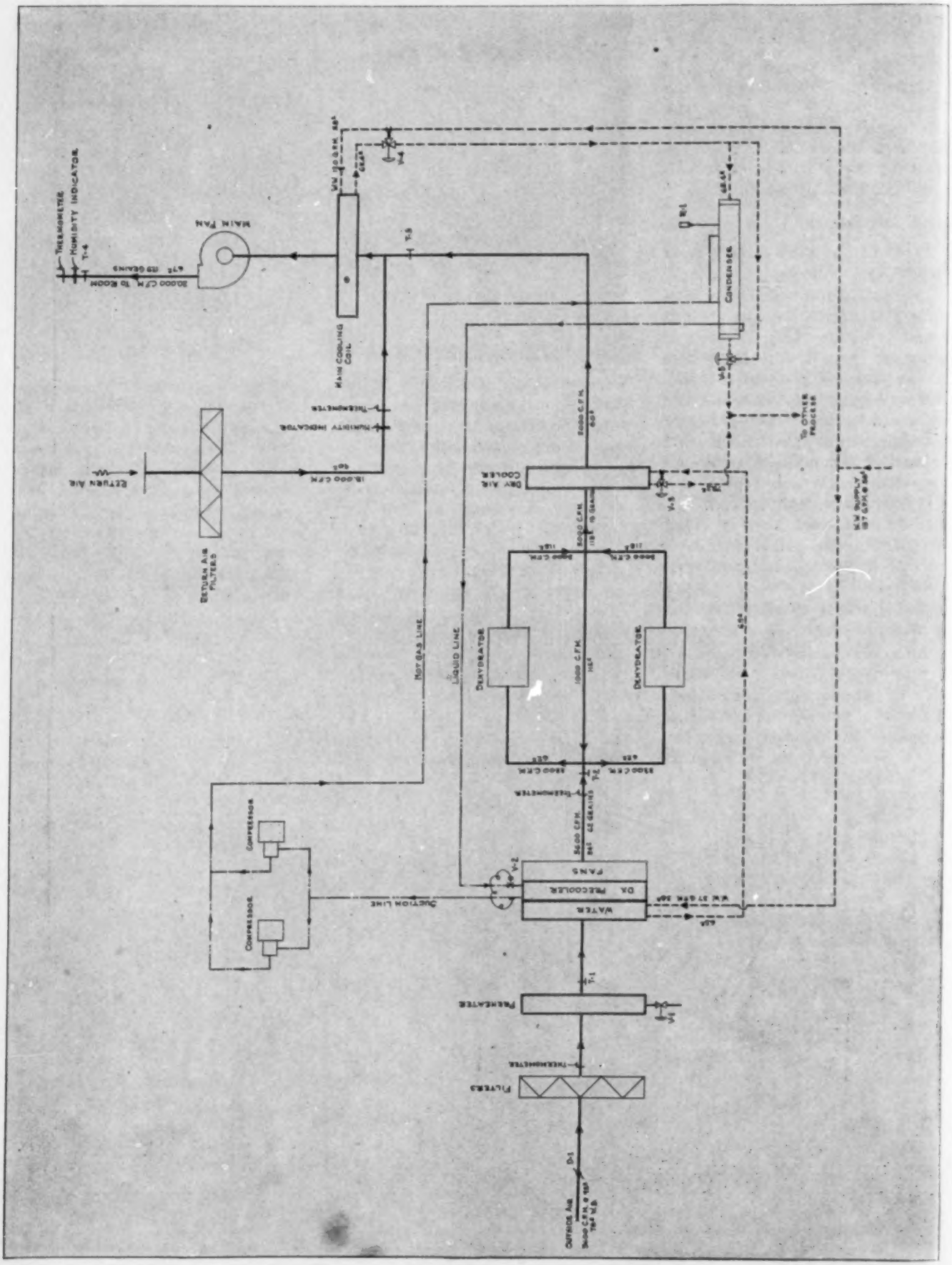


Here's how the air is treated during the conditioning cycle. Design room conditions were 90 F and 10 per cent

two complete sets of apparatus. To reduce spare part inventory requirements, the sets of apparatus are duplicates in all respects. Bear in mind that the process is continuous 24 hr per day, seven days a week.

The air cycle at peak load is as follows (see flow diagram below):

1) Outside air (5600 cfm) at 95 F dry bulb and 78 F wet bulb is taken from above the foundry



The principal need for automatic controls is to hold the room temperature constant and establish the upper humidity level—the essential factors

DESCRIPTION OF OPERATION

WHENEVER THE MAIN FAN RUNS, SOLENOID AIR VALVE E-1 IS ENERGIZED AND OPENS OUTSIDE AIR DAMPER D-1.

THERMOSTAT T-1, IN THE DISCHARGE OF THE PREHEAT COIL, CONTROLS STEAM VALVE V-1 TO MAINTAIN 45 DEGREES.

THERMOSTAT T-2, IN THE DISCHARGE OF THE PRECOOLING COILS, CONTROLS MODULATING ATTACHMENT ON THE THERMOSTATIC EXPANSION VALVE V-2. ON A FALLING TEMPERATURE T-2 DECREASES ITS BRANCH PRESSURE TO GRADUALLY LIMIT THE OPENING OF V-2 AS DETERMINED BY THE EXPANSION VALVE BULB. CUMULATOR C-1 POSITIVELY CLOSES V-2 WHENEVER T-2 CALLS FOR LESS THAN A PREDETERMINED MINIMUM OPENING, TO PREVENT SHORT-CYCLING OF THE REFRIGERATION COMPRESSORS.

THERMOSTAT T-3, IN THE DISCHARGE OF THE DRY AIR COIL, CONTROLS MIXING VALVE V-3 TO MAINTAIN 80 DEGREES.

THERMOSTAT T-4, IN THE MAIN FAN DISCHARGE, CONTROLS MIXING VALVE V-4 TO MAINTAIN 67 DEGREES.

PRESSURE REGULATOR R-1 CONTROLS MIXING VALVE V-5 TO MAINTAIN A PREDETERMINED FREON PRESSURE IN THE CONDENSER.

WHENEVER THE MAIN FAN STOPS, SOLENOID AIR VALVE E-1 IS DEENERGIZED AND CLOSES OUTDOOR AIR DAMPER D-1. E-1 ALSO EXHAUSTS AIR FROM THERMOSTAT T-2 SO THAT THERMOSTATIC EXPANSION VALVE V-2 IS POSITIVELY CLOSED WHENEVER THE FAN IS NOT RUNNING.

MANUAL SWITCH S-1 IS PROVIDED SO THAT THERMOSTATIC EXPANSION VALVE V-2 MAY BE MANUALLY OPENED OR CLOSED INDEPENDENTLY OF THERMOSTAT T-2, FOR PURPOSES OF SERVICING THE SYSTEM.

roof and drawn through viscous type cleanable air filters.

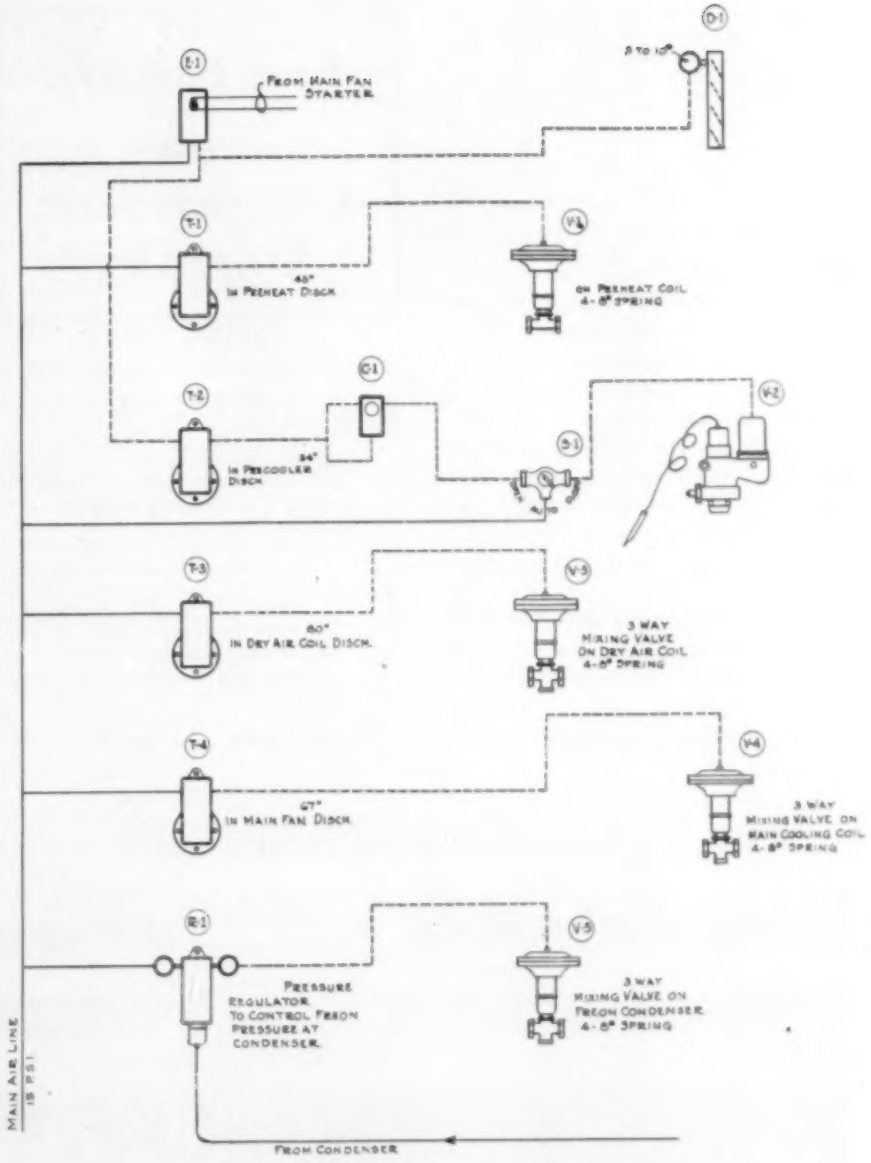
2) A preheater selected to heat 5600 cfm from 0 F to 45 F is provided for winter operation.

3) The air is next drawn through a precooler which consists of four rows of well water precooler coils, six rows of direct expansion coils, and multiple centrifugal fans. Precooling is accomplished by use of 37 gpm of well water entering at 58 F and leaving at 65 F. Load on the direct expansion coils, amounting to 337,000 Btu per hr at 40 F suction temperature, is handled by two equal sized "Freon-12" 10 hp compressors operating on a common water cooled condenser. Air leaves the precooler at 54 F saturated (62 grains per lb).

4) Each silica gel unit dehydrates a mixture of 2800 cfm of precooled air and 500 cfm of recirculated dry air to a moisture content of 13 grains per lb. The air leaves the dehydrator at 115 F. An allowance of 300 cfm was made for leakage of dry air from each unit. Silica gel reactivation is accomplished by use of 960 Btu gas.

OPPOSITE

The flow diagram for the dehumidifying system which maintains core storage room conditions of 90 F dry bulb and 10 per cent relative humidity. Note that a combination of well water, direct expansion refrigeration, and silica gel dehydration is employed. The well water, after precooling the air, is re-used for refrigerant condensing as well as process purposes



The moisture content of the leaving air is 13 grains per lb, which is lower than the 20.8 grains per lb previously given as the design condition. This drop in dew point was calculated as follows:

$$\frac{38{,}700}{1050} \times \frac{7000}{60} = 4300 \text{ grains per min, total from moisture seepage}$$

$$\frac{4300 \times 13.9}{10{,}000} = 6.0 \text{ grains per lb, required drop}$$

where 38,700 = Btu per hr equivalent of moisture seepage, 1050 = latent heat of water vapor, Btu per lb, 7000 = grains per lb, 60 = min per hr, 13.9 = specific volume of air in cu ft per lb, and 10,000 = air volume, cfm.

Room design condition 20.8—6.0 = 14.8 grains per lb required supply air moisture content. Using the full capacity of standard size dehydrators brings this down to 13.0 grains per lb.

5) Dry air (5000 cfm) enters the dry air cooler at 115 F and is cooled to 80 F by re-use of the 37 gpm from the precooler, heating this water quantity to 75.2 F.

6) Filtered return air (15,000 cfm at 90 F and 79 grains per lb) is mixed with the dry air (5000 cfm at 80 F and 13 grains per lb) and drawn through the main cooling coil to be cooled to 67 F. This cooling coil uses 120 gpm of water through a temperature range of 58 F to 65.4 F.

Total fan capacity was calculated as follows:

$$\frac{1{,}000{,}000}{1.08 \times (90\text{-}67)} = 40{,}000 \text{ cfm}$$

(20,000 cfm per apparatus)

where 1,000,000 = sensible heat gain in Btu per hr, 1.08 = factor for con-

verting Btu per hr to cfm, and (90-67) = temperature difference between room and supply air.

7) Each main fan supplies 20,000 cfm of 67 F and 17.5 grains per lb air to the room through ductwork extending one-half the length of the room. Outlets are located to blow between the core racks which extend across the room.

8) For condenser water, re-use is made of the 120 gpm of water coming from the main cooling coil at 65.4 F. Use of this quantity of fairly cool water results in a refrigerant condensing temperature of 82 F, explaining how 14 tons capacity can be provided by 10 horsepower compressors.

The Automatic Control System

The principal need for automatic controls is to hold the room temperature constant and establish the upper humidity limit. Obviously, no low limit of humidity is required. Operation of the pneumatic control system is as follows (see the diagram):

Whenever the main fan is in operation, a solenoid air valve is energized and opens outdoor air damper *D-1*. Thermostat *T-1*, in the preheat coil discharge air stream, controls steam valve *V-1* to establish a low temperature limit of 45 F during winter operation. Thermostat *T-2*, in the precooling unit discharge air stream, controls modulating attachment on the thermostatic expansion valve *V-2*. On a falling temperature *T-2* decreases its branch pressure to gradually limit the opening of *V-2* as determined by the expansion valve bulb. A cumulator positively closes *V-2* whenever *T-2* calls for less than a predetermined minimum opening, to prevent short cycling of refrigeration compressors.

Thermostat *T-3* in the dry air cooler discharge air stream, controls mixing valve *V-3* to maintain 80 F. Thermostat *T-4*, in the main fan discharge air stream, controls mixing valve *V-4* to maintain 67 F.

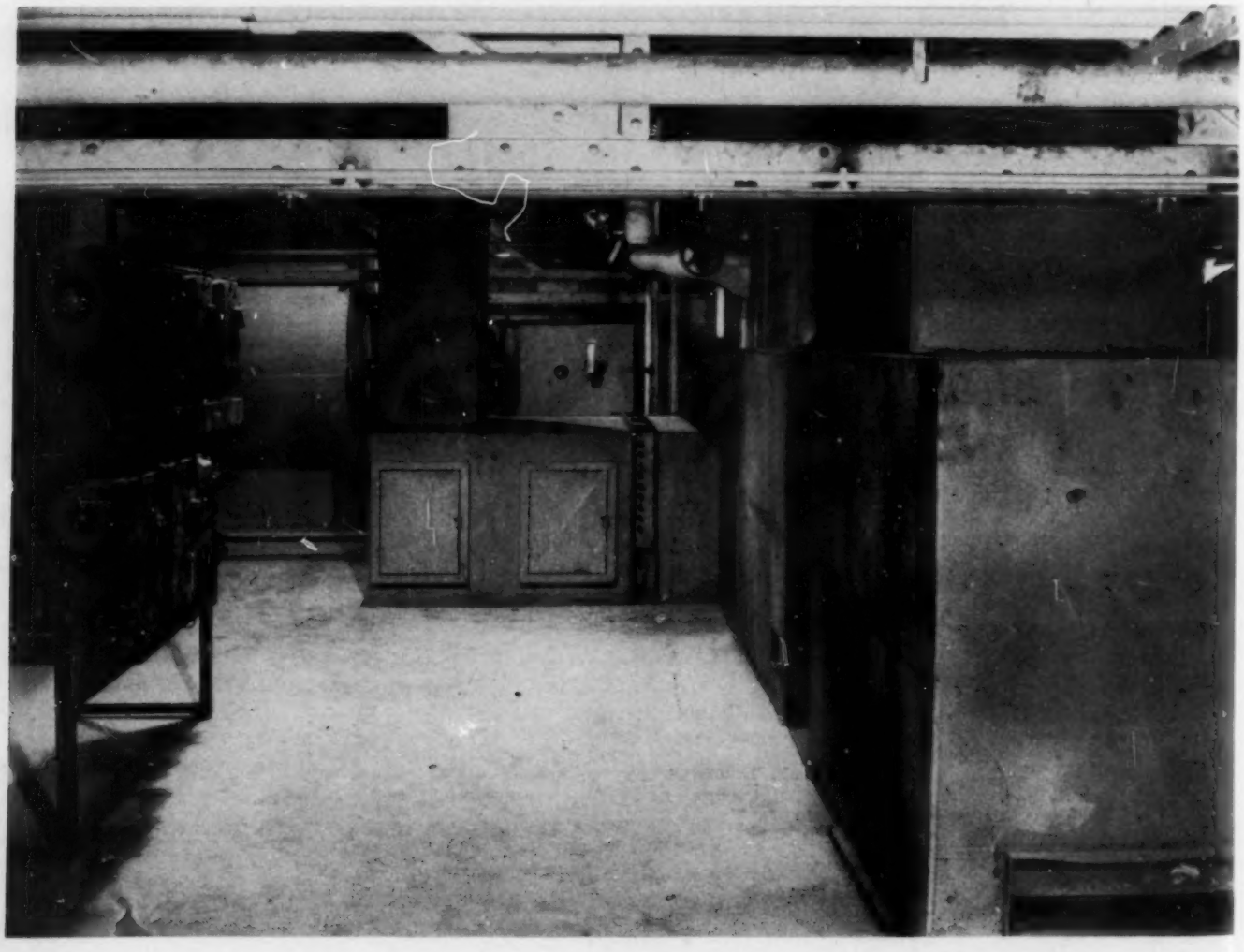
Pressure regulator *R-1* controls mixing valve *V-5* to maintain a predetermined refrigerant pressure in the condensers.

In addition to the above operating controls, temperature and humidity indicating devices are mounted in the return air stream (indicating room conditions) and the main fan discharge air stream. Each compressor is provided with high and low pressure cutouts; each condenser has high pressure protection; and each dehydrator has the necessary gas burner protective devices. All motors, of course, have thermal protection.

Keep Fighting!

1. Save fuel.
2. Conserve paper.
3. Buy war bonds.

Each silica gel unit dehydrates a mixture of 2800 cfm of precooled air and 500 cfm of recirculated dry air to a moisture content of 13 grains per lb



SAM LEWIS' PAGE

By Samuel R. Lewis, Consulting Mechanical Engineer, Chicago, and a Member of HPAC's Board of Consulting and Contributing Editors

Will Postwar Air Conditioning for Comfort Change Radically?

I AM asked to say what I think about the air conditioning which may be generally available to the public after the war. This request doubtless applies to refrigerated air conditioning designed particularly for comfort.

Due to diversion of material to war, there has been allowed practically no air conditioning *for comfort*. Thus, there has piled up a very great demand for comfort cooling which must be satisfied at the earliest possible moment.

It does not seem likely to me that there will be any immediate radical improvements in refrigerated air conditioning when civilian construction is resumed. I do not know that we need to worry about radical improvements. "Freon" is a pretty good refrigerant. Cooling towers and evaporative condensers are capable of fulfilling their promises. Drilling of wells for cold water continues to be a gamble.

Evaporators and convectors made of steel may or may not endure, but eventually copper and the new plastics for tubing will be generally available. It will be a relief again to install electric motors that are not arbitrarily overloaded by government decree. The manufacturers of automatic temperature controlling devices have progressed remarkably due to the experience with industrial war plants.

I believe and hope that—based on their industrial experiences—designers of comfort air conditioning systems will devote especial attention to the following items:

1) Delivery of air the year around to each room at optimum temperature for that room, independent of the air delivery temperature at the time to any other room.

2) Continuous air supply to each room with variable air delivery temperature rather than variable air delivery volume at fixed temperature.

3) Commensurate air exhaust or relief for the entire plant automatically balanced with variations in volume of outside air supply. There may be an exhaust fan for every supply fan, with cross connections and free areas to permit up to 100 per cent outside air supply or 100 per cent recirculation.

4) The war experiences in many different buildings with various kinds of heating and cooling systems indicate a growing trend toward control of indoor temperature by means of thermostats responding to outdoor temperature.

5) There is a decided trend toward use of water as the heat carrier between the air and the heating plant or evaporator. By this arrangement the same convectors and piping and insulation, the last being no small matter, may serve and earn interest on the investment the year around.

6) In general, experience with blackout, completely air conditioned manufacturing plants and their offices has been exceedingly favorable, so that extended blackout construction with elimination of the variable solar heat factor and with stabilized electric illumination and improved building insulation will have serious consideration.

Preventing Moisture and Frost Formation on Show Windows

A FRIEND in a midwestern city wants to know what I think about a project he has in mind to prevent obscuring of show windows with dew or frost. He wants some recommendation for air velocity, temperature, and the shape of the outlet.

The deposition of dew is governed principally by the temperature of the glass surface and by the amount of moisture in the interior air. The moisture problem on the show windows of mercantile establishments is more serious with food stores than with dry good stores, and more serious as the percentage of human occupancy increases. Vapor from cooking and dishwashing equipment, such as that from lunch counters, coffee urns and the like, affects the problem.

If the show window spaces are sealed off practically airtight from the general interior spaces there is usually little trouble about moisture condensing on the glass. On any cold winter morning one sees many show windows with clear areas where ordinary recirculating fans blast warm air against them. This improvement is due to the warm air having kept the temperature of the interior glass surface warmer than the dew point.

The ordinary slotted defrosters in modern automobiles sending a vertical jet of warm air parallel with the glass of the windshield apparently accomplish a satisfactory result. The temperature of the air probably does more good than does the speed of delivery. I have not measured the air delivery slot in my car but I guess it to be about 1/48th of the windshield height.

If I were to design an apparatus to keep moisture from forming on a show window I would try first a jet of air having a width parallel with the glass about 1/50th of the height or width of the window to be served by the jet, and I would draw the air supply to the small radial flow fan through a funnel-like air intake close to or above a radiator. The velocity of the air blanket emerging from the slot should be high. I think that the speed and temperature of the air are more critical than the width of the slot.

MEASURING the FLOW of FLUIDS

Knowledge of the quantity of fluid flowing through a pipe line is essential or desirable in much industrial and engineering work. Orifices and manometers are invaluable for measuring flow rates both on the job and in the laboratory; it has therefore been the purpose of the articles of which this is the sixth installment to present the data necessary for the selection and use of such flow-measuring equipment . . . The author, William Goodman, consulting engineer, the Trane Co., and a member of HPAC's board of consulting and contributing editors, discusses this month the construction of a U-tube manometer and its proper manipulation.

SOME OF those who find it necessary to meter the flow of fluids may find it difficult on occasion to obtain manometers and orifices. As a consequence of the war, even those with fairly high priorities sometimes may be forced to wait for a considerable period for the delivery of equipment; those whose priority numbers are low or who have no right to obtain a priority at all may find it virtually impossible to obtain equipment. The instructions in this article may offer a solution to such difficulties; they also serve to indicate some of the considerations involved in the design and construction of commercially-available flow measuring equipment.

U-Tube Manometer

Either one of two types of manometers can be built for measuring the pressure difference across the orifice. The one illustrated in Fig. 10 is a U-tube manometer. The second type of manometer, to be discussed later, has only a single tube. The U-tube manometer is the easier to build, but suffers from the disadvantage that both mercury columns must be read on the scale in order to obtain the difference in the height of the mercury in the two legs of the U-tube. This is not quite as difficult as it appears. The single-tube manometer, because the pressure difference can be obtained by reading only a single column, is likely to be more accurate and is certainly easier and quicker to read. However, it is somewhat more difficult to build.

Referring to Fig. 10 the chambers marked "A" can be cut from sections of 2 in. pipe and should be about 1¼ in. long as shown. Weld flat plates over both open ends of the pipe to form a sealed chamber. These chambers should be set with their flat sides vertical. In the bottom and top of these chambers, weld ⅛ in. IPS pipe couplings. The couplings can be curved with a half-round file to fit the pipe contour. Before welding these couplings in place, drill 5/16 in. holes through the top and bottom of the chambers "A" as shown in Fig. 10. The purpose of the two chambers marked "A" is discussed in the next section.

To connect the glass tubing into the bottom couplings of the chambers "A" of Fig. 10, use *steel* compression connectors. The connectors shown in Fig. 10 are for 5/16 in. OD tubing and ⅛ in. IPS male thread. Before installing, drill out the coupling with a 5/16 in. drill. This will permit an 8 mm OD glass tube to slide through the connector easily and at the same time will remove the cadmium plating from the interior surfaces likely to come in contact with mercury. Throw away the compression sleeve ordinarily supplied with this connector; use instead any packing suitable for the fluid being measured. Strands from graphite impregnated twist packing are quite satisfactory for packing the glass tubes against water or steam.

Pyrex glass tubing of 8 mm outside diameter (very nearly 5/16 in.) can be obtained from most laboratory supply houses. The inside diameter of such a tube will be about 6 mm. The tubing can be bent quite easily after it is heated over an open flame. However, if you do not feel confident of your ability to bend the tubing, a builder of neon signs could bend the tubing in a few minutes at small cost.

Into the top couplings of chambers "A" of Fig. 10 screw ⅛ in. tees with pipe plugs in the top. Connect the side outlets with either ⅛ in. pipe or ¼ in. tubing to the orifice connections. Install a bypass connection with a valve "2" and a vent valve "3" between the pipe connections to the orifice. Valves "1" and "4" should be installed at the manometer in the pipe connections to the orifice.

All parts of the manometer which come in contact with mercury must be either iron or glass. If either copper or brass is used, an amalgam will form and leaks will develop. Inasmuch as the plugs at the top of the ⅛ in. tee are used for filling the manometer with mercury, this means that all material below the elbows marked "B" and including these elbows themselves should be made of steel or glass. No nonferrous material of any kind should be used in this portion of the manometer. Material between the elbows "B" and the orifice may be either ferrous or nonferrous, or whatever material is required for the fluid being metered.

The longest length of glass tubing usually stocked by laboratory supply houses is 4 ft. With such a length, the U-tube manometer illustrated in Fig. 10 cannot be much more than about 22 or 23 in. in length after allowing for the U-bend. If a longer U-tube manometer is required, it can be made of two separate lengths of glass tubing connected together at the bottom by steel tubing, and steel compression connectors of the same type as those previously described for connecting the upper end of the glass tubes to the chambers "A" of Fig. 10. The open end of the glass tubing should always extend beyond the shoulder inside the steel compression connector. This applies equally to both the upper fitting and to the lower one if a lower one is used.

Although an ordinary yardstick can be used, a scale divided into tenths of an inch is much more convenient. Such a scale can be

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made by covering either an ordinary yardstick or a strip of steel with white enamel. Then a scale with inches divided into tenths can be ruled with black drafting ink. The scale can then be finished with a protective coat of shellac. The scale should be mounted on brackets so that the edge of the scale lines up with the center of the glass tube. A scale mounted in this manner makes it easy to line up the graduations visually on the scale with the edge of the mercury column.

Manipulating U-Tube Manometer

The U-tube manometer of Fig. 10 can be filled with mercury by unscrewing one of the top plugs and pouring the mercury into the top of the tube through a funnel. The glass tubing should be filled approximately halfway with mercury. When the manometer is in use, the mercury will fall in one leg and rise in the other. Mercury weighs about 0.49 lb per cu in. To fill a 12 in. length of 8 mm OD by 6 mm ID glass tubing requires very nearly 0.26 lb of mercury. To fill both legs of a 24 in. long U-tube manometer to the halfway mark requires approximately ½ lb of mercury. For a 36 in. long U-tube manometer with steel tubing at the bottom, about 1 lb of mercury is required. Before filling, the manometer should be thoroughly cleaned, preferably with carbon tetrachloride, to remove all grease and dirt. Allow the surfaces to dry before pouring mercury into the instrument.

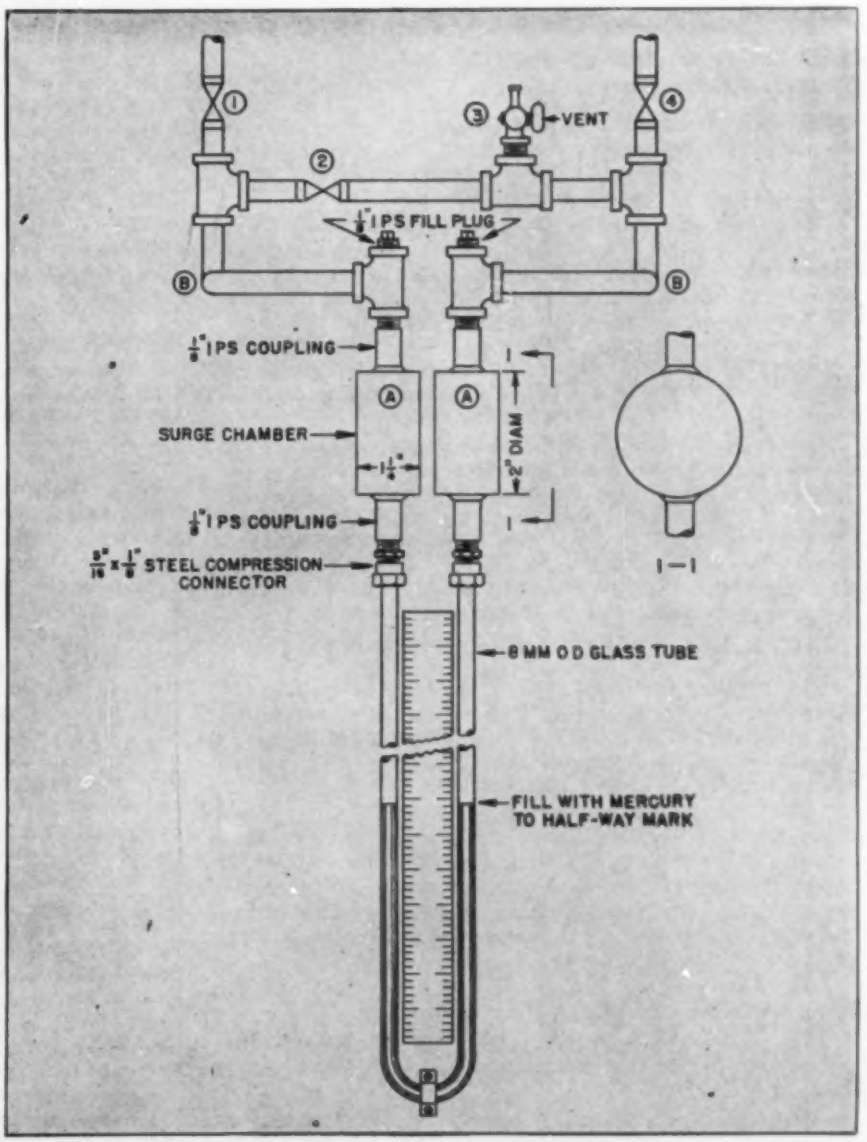
During filling, the mercury falling down into the glass tube will not form a solid column, unless you are unusually skillful or lucky. Instead, air will probably be trapped between pellets of mercury. The easiest way of breaking these pellets and forming a solid column of mercury is to insert a *steel* wire through the fill plug at the top. By pushing the wire far down into the glass and then gently moving it up and down, the pellets of mercury can be broken and made to unite in a solid column.

Valves "1" and "4" should be closed and valves "2" and "3" open when the manometer is connected to the tubing from the orifice. For purposes of description, valve "1" will be assumed to be in the tubing from the upstream or high pressure side of the orifice, and valve "4" in the low pressure or downstream side of the orifice. Actually it does not matter which side of the manometer is connected to the high pressure side of the orifice.

To vent air from the tubing connections between the orifice and the manometer, close valve "4" of Fig. 10, open valves "2" and "3", and crack valve "1" open. Air will vent from the upstream connection. Next close valve "1" and crack valve "4" open to allow air to vent from the downstream connection. Any small amount of air trapped at the top of the two surge chambers "A" can be vented by closing valves "1", "3", and "4", and opening valve "2". Next just barely crack open the fill plugs at the top of both chambers "A". Next crack valve "1" slightly open. This will force air out through the fill plugs. After venting is completed, screw the plugs in tightly and close valve "1".

To measure the flow through the orifice, vent valve "3" should be closed and bypass valve "2" should be wide open. Now crack valves "1" and "4" open. Close valve "2" slowly, meanwhile watching the mercury column so that it does not rise too fast in the glass tube. As valve "2" is closed, the mercury will rise more and more slowly as it approaches its equilibrium position. Valve "2" can finally be closed tightly when the mercury appears to be almost in its final position. After valve "2" is closed, the mercury column will probably pulsate up and down due to pressure variations in the pipe line. These pulsations

Fig. 10—U-tube manometer details



can be dampened to a considerable extent, although they probably cannot be eliminated completely, by turning valves "1" and "4" to an almost closed position so that they are just barely cracked open. In this way the worst of the pulsations can be eliminated. The height of the mercury column can now be read and this measurement used to determine the quantity of fluid flowing through the orifice.

Bypass valve "2" is used to bring the mercury column up to reading position in order to prevent the mercury from shooting through the glass tubing into one of the surge chambers "A" of Fig. 10. This can occur either because of a sudden pressure surge or because the pressure difference across the orifice is too great for the length of the manometer. The pressure difference can be too great, of course, only if the quantity flowing through the orifice is greater than the quantity for which the orifice has been designed. Occasionally the quantity of fluid flowing through a pipe is much greater than has been anticipated. For this reason it is well to have a liberal margin of length when selecting a manometer length for a given orifice and flow quantity.

If the mercury does, as occasionally happens, shoot through the glass tubing, the mercury will be caught in the surge chambers "A" and will not enter the main piping system where it can cause trouble. When the mercury shoots into the surge chamber, fluid from the upstream connection flows around through the glass tubing to the downstream connection. As the fluid passes through the low pressure chamber "A", it bubbles through the mercury trapped in this chamber.

When the mercury is forced out of the glass tube of the manometer, close valves "1" and "4" and open valves "2" and "3". The mercury will drop down into the glass tubing. To place the manometer in service again, it will probably be necessary to repeat the venting operation and to use a steel wire to force the pellets of mercury into a solid column as previously described.

Do not confuse the purpose of the chambers marked "A" in Fig. 10 with the chambers marked "A" in Fig. 5, on p. 527 of the October 1943 HPAC. Both sets of chambers must be used when measuring steam or any other condensable vapor. The surge chambers of Fig. 10 are needed to prevent the escape of mercury, whereas the chambers in Fig. 5 are needed only to provide a steady head of liquid above the mercury.

M-28 Order on Refrigerants Amended Once More

The War Production Board issued November 30 an amendment and an interpretation of conservation order M-28 covering commercial uses of dichlorofluoromethane, or as it is more commonly known, "Freon-12."

The amendment clarifies those paragraphs which cover the uses of other types of refrigerants, specifically those designated as groups 2 and 3, under the order. In any instance where all refrigerants in both groups are prohibited for use under the American Standard Safety Code for Mechanical Refrigeration, "Freon-12" may be used if the system is not one for which all deliveries are prohibited under list A of the order. The amendment also clarifies several other minor provisions of the order.

The interpretation limits the purchases of "Freon-12" to the necessary usable quantity. This interpretation is designed to prevent owners and lessees of refrigerating equipment using "Freon-12" from acquiring quantities in excess of their immediate essential requirements. The interpretation also relieves restrictions upon owners of systems who might have had small quantities of "Freon" on hand for their own uses prior to the issuance of M-28.

Following are excerpts from the order as amended November 30:

"(b) *Systems for which no deliveries are permitted,* (1) No person (including users, dealers, and other suppliers, and producers) shall deliver, or accept delivery of, any F-12 gas for use in, or for resale for use in any new or used system which is of a type referred to in List A.

"(2) During the period from November 12, 1943, through March 31, 1944, no person (including users, dealers, and other suppliers, and producers), shall deliver, or accept delivery of, any F-12 gas for use in, or for resale for use in any new or used system of any type (not in List A) unless the system must be operated under one or more of the following conditions:

"(i) Where an air cooled condenser is used, and the ambient temperature is 110 F or higher or

"(ii) Where the saturated refrigerant temperature corresponding to the suction pressure is less than minus 10 F or

"(iii) Where aluminum or magnesium alloys or rubber (except synthetic rubber) have been used in construction of the system and come in contact with the refrigerant, and are not easily replaceable; or

"(iv) Where the system is for use aboard ship, or outside of the continental United States by the Army, Navy, Maritime Commission or War Shipping Administration; or

"(v) Where the total operating charge required to operate the system is ten (10) pounds or less of F-12 gas and the system was in operation on November 12, 1943, and is used for food preservation or for storage of penicillin, blood serum, blood for plasma, blood plasma, biologicals and bacteriologicals; or

"(vi) Where the use of no Group 2 or Group 3 refrigerants, as defined in the American Standard Safety Code for Mechanical Refrigeration, ASRE Circular No. 15, ASA-B 9-1939, as approved by the American Standards Association April 20, 1939, is permitted by the Code; or

"(vii) Where the system is used in a sealed railroad car or sealed bus.

"(The above restrictions apply not only to systems used for ordinary civilian purposes, but also to those owned, operated, or used within the continental United States by the Army, Navy, Maritime Commission or War Shipping Administration, including post exchanges and ships service stores, other than those used aboard ships.)"

"(f) *Miscellaneous provisions*—(1) *Applicability of regulations.* This order and all transactions affected thereby are subject to all applicable regulations of the War Production Board, as issued and amended from time to time.

"(2) *Reports.* (i) Each equipment manufacturer who wishes to secure delivery of F-12 gas during any month for charging systems or parts produced by him, or for factory repair and charging of sealed or hermetic condensing units, shall file with the War Production Board, on or before the 15th day of the preceding month a report on Form WPB-3326, prepared in accordance with the instructions for such form.

(ii) Any person wishing to secure F-12 gas during any month for ultimate uses (such as testing coaxial cable for leaks) other than the charging of new or used refrigeration or air conditioning systems or parts or use in insecticide, shall file with the War Production Board, on or before the 20th day of the preceding month, a report by letter, in triplicate, showing the minimum amount required for the month, the purpose for which required, and the amount used during the preceding calendar month for that purpose."

pH

What It Means and How It's Measured

ENGINEERS OF plants and buildings encounter many problems involving water chemistry, such as boiler metal scaling, pitting, and corrosion; clogging of spray nozzles; water pipe encrustation; steam and condensate pipe corrosion; slime formation in air washers and cooling towers; swimming pool purification; water supply softening or filtration or both; scaling of water heaters, etc. It is our purpose here to consider a chemical concept that not only is common to all problems in water chemistry, but is likewise useful in many other arts, as dyeing and tanning, food preparation and brewing, electroplating, lithography, pharmaceuticals, etc. While much scientific research has been brought to bear on hydrogen ion concentration, it is not necessary that the engineer have any profound knowledge of chemistry in order to utilize the benefits of hydrogen ion control. But a few simple and fundamental facts regarding it will be decidedly helpful to anyone who finds it necessary or advisable to make periodic tests of hydrogen ion concentration.

Hydrogen Ion Concentration

Hydrogen ion *concentration* is essentially an accurate method of expressing degree of acidity or alkalinity. In this respect it is analogous to the Fahrenheit or Centigrade scales of temperature, or the Baumé scales of specific gravity, and determining hydrogen ion concentration is not much more difficult than reading a thermometer or a hydrometer. Hydrogen ion *control* is analogous to temperature or pressure regulation. And just as convenience has required that a symbol be used to express degrees Fahrenheit (F), so a symbol is used to express hydrogen ion concentration. The symbol is "pH".

Acids, Bases, and Salts

It will be necessary, for the purposes of this article, to define three types of chemical substances: acids, bases, and salts. An acid is a substance which when in solution releases hydrogen atoms carrying a positive electrical charge. A base (also known as hydroxide or alkali) is a substance which when in solution releases hydroxyl (oxygen combined with hydrogen in proportion) groups or radicals carrying a negative electrical charge. Simultaneously, of course, each substance also releases an equivalent quantity of atoms or atom groups of opposite polarity. Thus, hydrochloric acid (HCl) in solution releases positive hydrogen atoms and negative chlorine atoms; and sodium hydroxide (NaOH) releases positive sodium atoms and negative hydroxyl groups. These electrically charged atoms or atom groups in solution are called ions. When the positive ion of a base combines with the negative ion of an acid, the result is a salt. At the same time, the positive hydrogen ion of the acid combines with the negative hydroxyl ion of the base to form water (H_2O or HOH). The chemist expresses all these facts by means of an equation, which is here written in ionic form:

$$H^+Cl^- + Na^+OH^- \rightarrow Na^+Cl^- + H^+OH^-$$

In words, this equation states that hydrochloric acid reacts with sodium hydroxide to form sodium chloride (NaCl) and water.

All acids, bases, and salts do not undergo the same percentage of ionization even at equivalent concentration and the same temperature. Since the above equation indicates that the interaction of substances is a recombining of ions, it might be assumed that those substances which are highly ionized are more active chemically than those less highly ionized. Such is indeed the case, and leads one rightly to conclude that hydrogen ion concentration must be related to chemical activity. Acids and bases which ionize readily or to a considerable extent are called active; those which ionize but slightly are called inactive. For any particular acid or base an equilibrium is established, depending upon the concentration and temperature. For phosphoric acid, for instance, one could write

$$H_3PO_4 \rightleftarrows 3H^+ + PO_4^{---}$$

which indicates that at equilibrium the rate at which the acid ionizes

Heating, piping, and air conditioning engineers and operating men encounter a number of problems involving water chemistry. The concept of hydrogen ion concentration not only is common to all such problems, but is likewise useful in many other arts. A profound knowledge of chemistry is not, however, necessary in order to understand hydrogen ion control and utilize its benefits . . . Kalman Steiner, a member of HPAC's board of consulting and contributing editors, gives here a discussion of the theory of hydrogen ion concentration and the meaning of the symbol pH.

into hydrogen and phosphate ions is balanced by the rate at which the ions recombine to form the acid. But if now either of the ions were removed from the system, the equilibrium would be upset and the rate of ionization would be increased so as to replace some of the ions that were removed. Suppose, for instance, that a small quantity of calcium hydroxide, $Ca(OH)_2$, were added. If other conditions were favorable, a salt, tricalcium phosphate, would be formed and being insoluble in water would be precipitated and therefore removed from the system. This upset of equilibrium would induce the ionization of additional quantities of phosphoric acid. This particular reaction is used extensively in treating water for boiler feed, and it has been established that the success of the process is dependent upon hydrogen ion concentration (pH).

The Equilibrium Constant

When any chemical reaction reaches equilibrium, the product of the concentrations of the left hand components equals the product of the concentrations of the right hand components multiplied by a constant. Using as an example the ionization of sodium chloride and designating concentration by enclosing the component in parentheses, we have

$$(NaCl) = k\,(Na^+) \times (Cl^-)$$

If now both sides of this equation be divided by the right hand member, we would have

$$\frac{(NaCl)}{(Na^+)\,(Cl^-)} = k$$

k is known as the equilibrium constant. For any given reaction, it varies with the temperature of the system.

pH Scale Is Logarithmic

The most neutral substance known is water. Since it is formed from the characteristic acid ion (H^+) and the characteristic base ion, hydroxyl (OH^-), there appears good reason for this. Actually, water ionizes very little, but to the extent that it does, there is as much reason for its being acid as alkaline.

Careful research has shown that at 77 F the equilibrium constant for the ionization of water is very closely 10^{-14}. Since each molecule of water that ionizes yields one hydrogen ion and one hydroxyl ion, and the product of the two concentrations is 10^{-14}, it follows that the concentration of each is 10^{-7}. The pH value is defined as the negative logarithm of the concentration. Inasmuch as the pH of water would therefore be 7, it also follows that a pH of 7 indicates chemical neutrality, since water is the most chemically neutral substance known. Values of pH above 7 are alkaline. Those below 7 are acid. Incidentally, the symbol pH was originally an abbreviation for the phrase "potential of hydrogen," which means the electrical potential existing in a solution of hydrogen ions.

Because of the logarithmic scale used, each value in it is 10 times greater than the one below and one-tenth as great as the one above. Substances having pH readings just above 7 are mildly alkaline; those with pH just below 7 are mildly acid. Boric acid solution, commonly used as an eyewash, has a pH of 5.2. Sodium bicarbonate, the principal ingredient of baking powder, in solution has a pH of 8.4. Acetic acid, which makes vinegar sour, has a pH of 2.9. The common laboratory acids, hydrochloric and sulphuric, in strengths often used, have respective pH values of 1.1 and 1.2. The usual concentrations of strong laboratory bases, sodium hydroxide and potassium hydroxide, show a pH of 13.

Meaning of Concentration

The term "concentration" indicates the total amount of a substance dissolved in a unit of the solution. Thus, a 10 per cent solution means that 10 grams of the substance are dissolved in 100 grams of solution. It is more convenient, however, to express solution concentrations in terms of normality. Using the expression "solute" to mean the substance dissolved, a *normal solution* is defined as one containing one *chemical equivalent* of solute per liter of solution. A chemical equivalent is computed by dividing the number of grams indicated by the molecular

Apparatus for colorimetric determination of pH

An electrometric pH meter

weight of the solute by the number of replaceable or ionizable hydrogen atoms or hydrogen equivalent.

To find the chemical equivalent, divide the gram-formula weight (molecular weight in grams) by the number of hydrogen atoms in the molecule, if an acid, or by the hydrogen equivalent, if a salt or base. Thus, hydrochloric acid would require one formula weight per liter of solution because the molecule HCl contains but one atom of hydrogen. On the other hand, the chemical equivalent of sulphuric acid is one-half formula weight because the molecule H_2SO_4 contains two hydrogen atoms. In the case of salts, the chemical equivalent is determined by the number of hydrogen atoms, of the corresponding acid, that have been replaced by metallic atoms. Since in sodium chloride, NaCl, one atom of hydrogen of hydrochloric acid has been replaced by sodium to form the salt, the chemical equivalent of this salt is one formula weight per liter. Similarly, because tri-sodium phosphate contains three sodium atoms that replaced hydrogen atoms of phosphoric acid, the formula weight of that salt is divided by three to find the chemical equivalent. For bases, it is perhaps easier to use as a guide the number of hydroxyl (OH) groups, since one hydroxyl group is chemically equivalent to one hydrogen atom. For example, as there are two hydroxyl groups in calcium hydroxide or lime $Ca(OH)_2$, divide the formula weight by two to determine the chemical equivalent.

Frequently, fractional normal solutions are needed, such as a *one-tenth* normal solution. The chemist denotes this by 0.1N. The weights required for such solutions are found quite simply by dividing by 10 the weights found for normal solutions in the preceding paragraph. Also, solutions more concentrated than normal are sometimes used, as *twice normal* (2N). To find solute weights for twice normal solutions, simply double the weight used in a normal solution.

The advantage of using normality to designate strength of solutions is that equal volumes of equal normalities of acid and alkali will exactly neutralize each other. Thus 35 cc of 0.1N HCl will exactly neutralize 35 cc of 0.1N NaOH, or 50 cc of 0.5N $Ca(OH)_2$ will just neutralize 100 cc of 0.25N H_2SO_4. From the fact that the atomic weight of hydrogen is 1, it follows that a normal solution of hydrogen ion would contain 1 gram of ionized hydrogen per liter. Since the logarithm of 1 is zero, such a solution would have a pH of 0. Were there 0.0001 grams of hydrogen per liter, the normality would be 0.0001, or 10^{-4}N, and the pH equals 4. It must be remembered that pH and normality of hydrogen *ion* refer only to the hydrogen that has become dissociated from the parent molecule and carries the positive electrical charge.

A very convenient method for indicating whether a solution is acid or alkaline is through the medium of a color changing substance called an indicator. The familiar litmus, generally applied by inserting a piece of litmus soaked paper into the solution, is red in acid and blue in alkali. Litmus changes color at true neutrality, or at a pH very close to 7. But it is not a delicate test, for a number of reasons. Other indicators used for actual titrations (process of adding measured volumes of standardized solutions) are methyl orange and phenolphthalein. Methyl orange gives a fairly sharp color change from yellow in alkaline solution to pink in acid solution, but the color change occurs at a pH of 4, or while the solution is on the acid side of neutrality. Phenolphthalein at pH of 9.3 changes from colorless in acid to pink in alkaline, but the solution is alkaline when color change occurs. Since in many industrial processes, particularly water purification, it is quite important to know exactly how strongly alkaline or acid a substance is, there have been developed accurate methods of determining pH.

Total and Active Acidity or Alkalinity

It is important to distinguish between *total* acidity or alkalinity and *active* acidity or alkalinity. Total implies the actual amount of acid or base present in solution, as determined by titration. Active implies only the quantity that is ionized, for only ionized portions of acids or bases participate in chemical reaction. But as the ionized portions are neutralized or otherwise altered chemically, additional portions ionize, and so on, until complete neutralization or chemical change has occurred. In water analysis, it is especially important to know the degree of ionization existing at any given moment, for that indicates the chemical activity or potential capacity of the water for accomplishing chemical change. For this reason it is quite desirable to know the pH of a water. From a knowledge of the pH it is possible to determine, for instance, whether a certain water supply will be corrosive, whether it is susceptible to certain methods of chemical treatment, or the extent to which a chemical reaction or change has progressed toward completion.

Neutralization Process Is Reversible

From the preceding discussion of neutralization of acid by alkali, or alkali by acid, it might be assumed that solutions of salts formed by such action are neutral. Such is not always the case, however. This is because the process of neutralization is reversible. Just as acid and alkali can react to form salt and water, so a salt can react with water to form an acid and an alkali. When this reverse of neutralization occurs it is known as hydrolysis. In water purification, hydrolysis can be of extreme importance. Consider, for instance, the hydrolysis of a salt of a weak acid and a strong base, sodium carbonate:

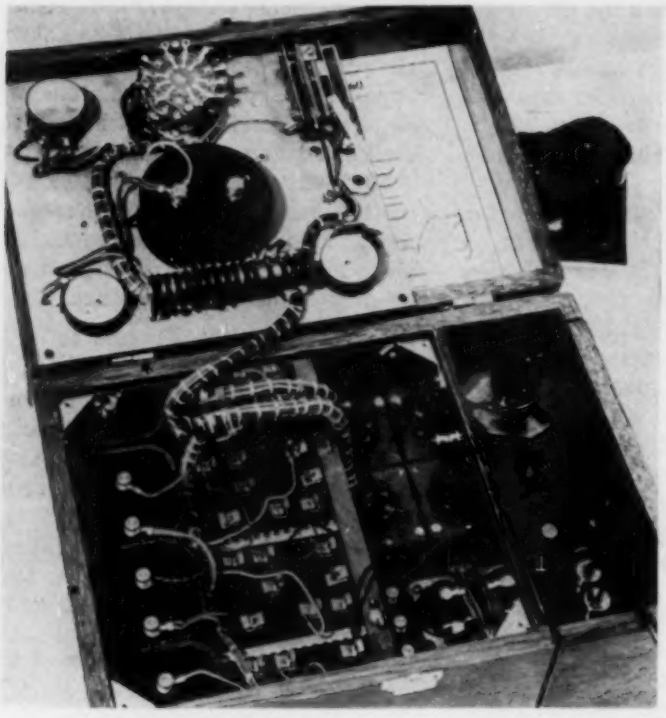
$$Na_2CO_3 + 2H_2O \rightarrow 2NaOH + H_2CO_3$$

Sodium hydroxide is a strong base and shows appreciable ionization. Carbonic acid is a weak acid and shows little ionization. Hence, it would be expected that a solution of sodium carbonate would be alkaline, and such is actually the case. Similarly, a salt of a strong acid and a weak base will hydrolize but will show an acid ionization. For instance, alum (aluminum sulphate), undergoes hydrolysis to form aluminum hydroxide and sulphuric acid. Aluminum hydroxide is not only a weak base, but is insoluble and precipitates from solution. This reaction is quite important in walter filtration, for the precipitate is known as a floc and assists in agglomerating smaller particles of sediment suspended in

water which can more readily be removed by filtration. In addition, the release of sulphuric acid reduces the alkalinity of the water. The proper application of alum to water can be controlled only if the pH is known.

Buffer Action

The phenomenon of hydrolysis is related to an aspect of hydrogen ion control known as buffer action. By this expression is meant the ability of a solution to resist change in pH when acid or alkali is added. This usually occurs when salts such as carbonates, phosphates, or acetates are present—i.e., salts of strong bases and weak acids. By reason of the equilibrium constant mentioned above, the ionization of compounds containing the same radicals is retarded should there already be in solution a substance containing that radical. Buffer action tends to stabilize pH, and makes possible the dilution of solutions when it is desired to measure pH colorimetrically and the solution contains a turbidity which would interfere with light transmission.



Inside arrangement of an electrometric pH meter

Determining pH Values

There are two principal methods for determining pH. The first is colorimetric and involves but little apparatus. The second is electrometric and requires rather elaborate equipment. The colorimetric determination is not precise, but is accurate enough for many applications. The electrometric method yields highly accurate results.

Mention has been made above of the use of indicators to register whether a solution is acid or alkaline. Colorimetric determination of pH is based on the fact that when equal amounts of certain indicators are added to equal volumes of solutions having the same pH, an identical color will be produced in each. While this rule is not exact, it is sufficiently close to permit of approximations that serve the needs of many control problems. If, for instance, a few drops of an indicator known as phenol red are used, the color changes will be found to vary from deep red at pH 8.4 to yellow at pH 6.8, with intermediate values giving various shades of red.

For colorimetric determinations of pH, color standards are prepared by adding 0.5 cc of an indicator to a small quantity (5 to 10 cc) of a solution having a known pH. Various indicators are available, each of which covers a certain portion of the range of pH from 0.2 to 13.6. An indicator known as bromcresol green, for instance, will cover the pH range from 3.8 to 5.4 and thymol blue will cover the range from 8.0 to 9.6. In this manner the entire scale is covered. These standards are quite stable and will not deteriorate over considerable lengths of time.

To make a determination of pH by the colorimetric method, it is merely necessary to have on hand color standards of the range involved, indicator for coloring the sample to be tested, and a means of comparing the color produced in the sample with the colors of the standards. The pH of the sample will be the same as the pH of the standard which it matches, or if no exact match is found in the standards then the pH of the sample lies between the pH values of the two standards that are respectively next darker and next lighter than the sample. Standards can be had in steps of 0.2 pH, so that results may be determined to the nearest 0.1 value. This is sufficiently precise for most purposes, but if greater precision is desired or required, recourse must be made to electrometric methods.

Use of Comparators

If the sample is clear and colorless originally, then the color produced in it by the indicator may be compared directly with the color standards. In many cases, however, the sample is either colored or turbid, or both, so that direct comparison would give erroneous results. To offset the effects of the original optical condition of the sample, comparators are constructed so as to permit blending the optical condition of the sample with the optical qualities of the color standards. This might sound complicated but actually is quite simple. Refer to the sketch below.

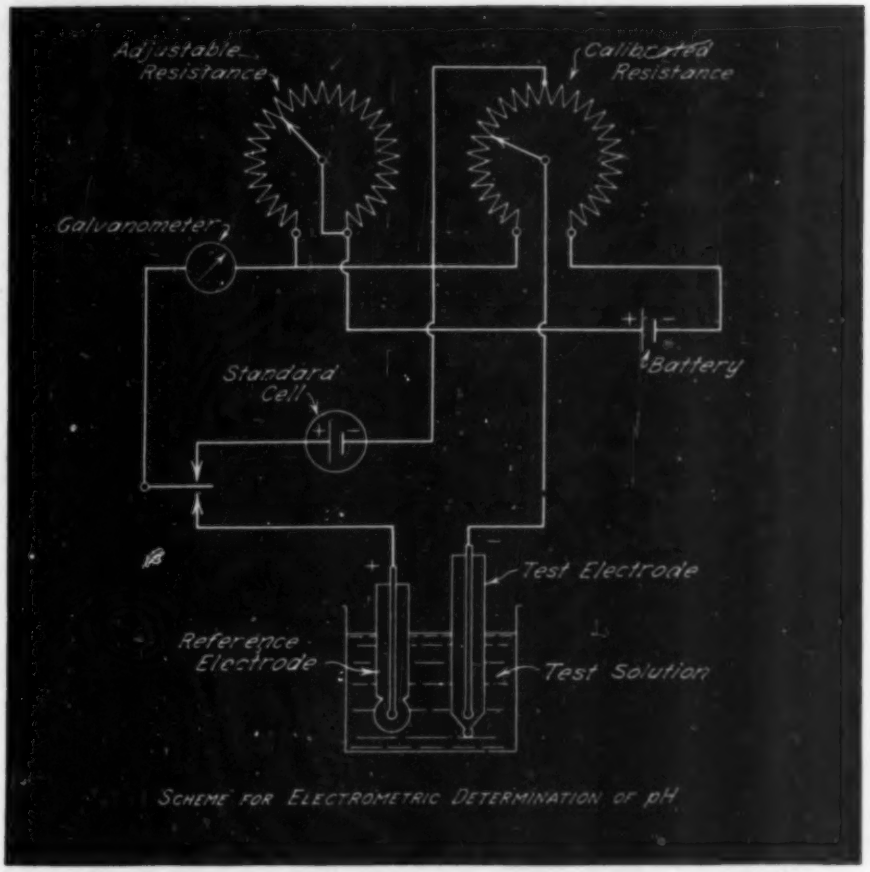
It will be noted that there are two rows each containing three test tubes. Each of the three tubes in the rear row (closer to the light

source) contains a quantity of the material being tested. Indicator is added only to the center tube of these three. In the front row, the center tube contains only distilled water, but the two outer tubes contain color standards differing by .2 pH. The observer looks through two tubes in series, therefore, and secures the optical effect of the sample merged with color standard, in the case of the outer tubes, or the effect of the sample and indicator plus distilled water in the center tubes. In typical commercial forms of comparators, the apparatus permits sliding or rotating alternate sets of color standards in this position, always bringing a tube of distilled water in front of the sample with indicator. It is thus possible to find the standard which just matches the sample with indicator, or the two standards which lie above and below the value of the sample.

When a sample is to be tested and nothing is known as to the pH range in which it falls, a rough determination is made by applying indicators starting from pH 7 until an approximation is had as to the applicable range of standards. While universal indicators, purporting to cover the entire range of pH, have been announced, it is not established that these indicators will give accurate results.

Dilution and Dialysis

Occasionally the turbidity or color of a liquid will be so intense that the standard colorimetric method cannot be applied. In some of these cases very close approximations can be secured colorimetrically by either of two methods: dilution or dialysis. The former depends for its accuracy upon whether or not the original solution is buffered, i.e., the presence in it of solutes which permit addition of distilled water without changing the pH value. Dialysis is a process employing a semipermeable membrane, through which hydrogen and hydroxyl ions can migrate but which will not pass more complex bodies; in this way a clear solution is obtained which can be subjected to colorimetry. But both dilution and dialysis should be employed only with extreme caution, and the initial results should be checked electrometrically before the methods are generally utilized for control work.



SCHEME FOR ELECTROMETRIC DETERMINATION OF pH

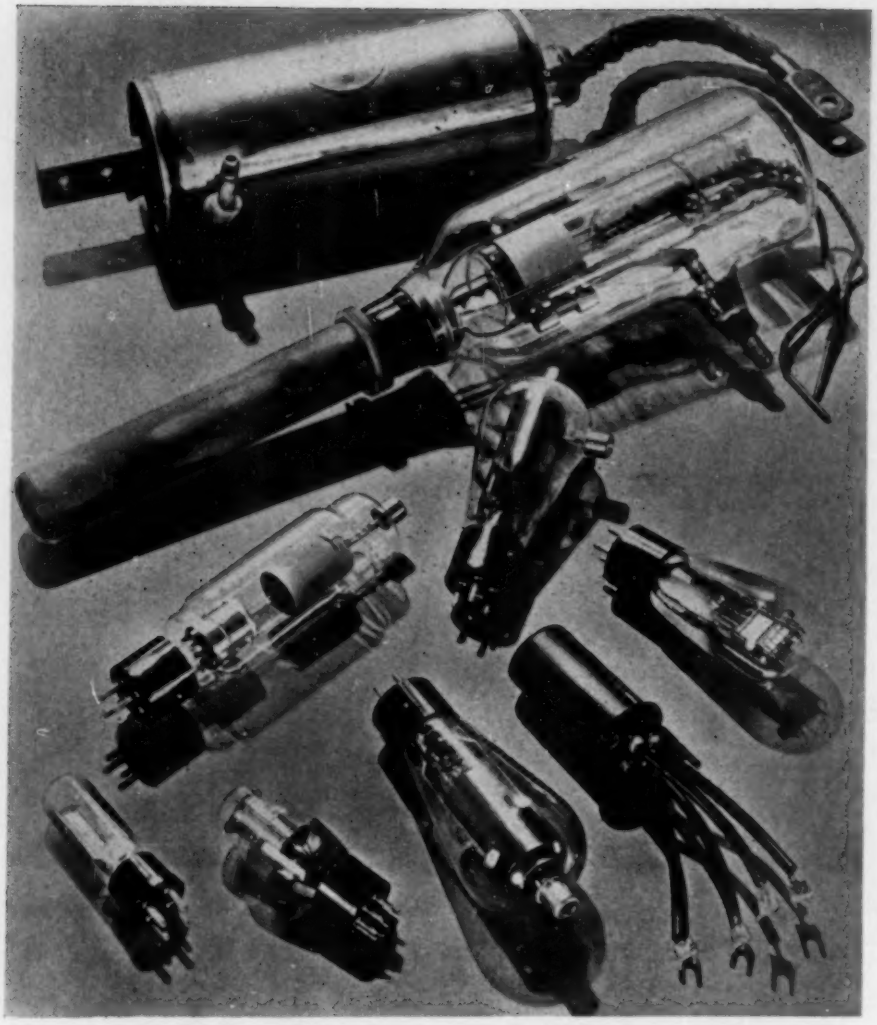
Electrometric Determination

Electrometric methods of pH determination must be resorted to whenever the sample is of such nature that it will not give accurate tests in colorimetry, or whenever greater precision than 0.1 pH is required.

It is well known that when two dissimilar electrical conductors are immersed in a solution of an electrolyte (acid, base, or salt), an electrical potential is established between the two conductors when connected externally to the solution. Ordinary dry cells and storage batteries are common examples of the application of this principle. In more concise language, a chemical reaction occurs between the electrode and the constituents of the solution (or paste, in case of a dry cell), and this reaction develops an electrical potential. Practically, it is required to have two electrodes in order to make a complete electrical circuit, so that ordinarily the measured potential (voltage) is the combined potential developed by the two electrodes. There is no satisfactory way of measuring the potential developed by a single electrode. When hydrogen ions exist in a solution, the potential developed between the solution and the cathode is a function of pH. In order to measure this potential, however, it is necessary to employ two electrodes, and since only the potential of one electrode is being sought, the potential of the other must be both known and constant. This is accomplished by using a standard (calomel) half-cell as one electrode. Then if suitable means are provided for measuring the total voltage of the system, the potential of the other electrode may be calculated.

The essentials of an electrometric determination apparatus are shown in the diagram. Internally, the circuit between the calomel electrode and test electrode is completed by a bridge of potassium chloride solution. Externally, the circuit passes from electrode to electrode through a potentiometer, which records the potential existing, and from which potential the pH of the test solution is determined.

FIGHT FUEL WASTE



The Electron Tube
Genie, Gremlin, or Jeep?

W. D. Cockrell, engineer, electronic section, industrial control division, General Electric Co., has had wide experience in the design and application of electronic equipment. He was asked to prepare a simple, fundamental article for distribution to those whose background was solely electrical, and here—with a few modifications—is the result. His easy-to-read style makes his discussion of interest and value to all engineers. . . . There are probably as many or more applications and possible applications of electronics in heating, piping, and air conditioning work as in any other field. Heating system controls, air conditioning controls, combustion controls and safeguards, valve control in process piping services, and many other uses of electronics are already employed. There will be many more uses in the future, so an understanding of electronics fundamentals is important to all of HPAC's readers.

THE AVERAGE industrial engineer, unfamiliar with electronics, who glances through almost any magazine—technical or popular—is apt to be overawed by the promises of electronic things to come. It is quite likely that his first impression will be that the electron tube is nothing short of a genie straight out of the Arabian Nights — a superhuman spirit of fantastic complexity and far too elusive for the average mortal to even comprehend.

Or he may take the opposite viewpoint. These odd looking electron tubes must fit into a class with the gremlins, mischievous little sprites, capable of much good, but more evil, and definitely to be shunned for as long a period as possible.

But on closer acquaintance, this electron "monster" loses most of its frightfulness, and turns out to be a friendly little jeep, rugged and reliable, capable of taking a terrific beating with minimum attention, while doing a mansize job.

Like the jeep, the electron tube can do its job 100 per cent, but it cannot win the war unless the rest of the army pitches in to do its share. The rest of the "army" consists of the infantry of rheostats, transformers, and capacitors; the artillery of motors, generators, and amplidynes.

What Are Electron Tubes Anyway?

Are tubes hard to understand? Anyone who understands the use of the simplest copper-oxide rectifier, the rheostat, and the direct current voltmeter, can become a tube expert after one easy lesson—well, anyway, he'll know as much about an electron tube and how it functions in an industrial circuit as many of us need to know.

In the first place, every true electron tube is a rectifier—composed of at least two elements or electrodes enclosed in a vacuum envelope made either of glass or of metal. One of the two principal elements of each tube is called a "cathode." The cathode is made of special materials, and is heated, usually by a small electric heater, to release electrons—those fundamental particles of negative electric current.

Once, in the dim, dark past of high school physics, we learned that anything charged positively attracts a negative charge. Then, in the next lesson, we learned that if the charge is negative, other negative charges are repelled. Thus, if we connect the other principal tube element, called the "anode," to a power source so that it is positive with respect to the cathode, the anode will attract the electrons from the cathode. But if

conditions are reversed, and the cathode is positive and the anode negative, no electron flow will take place, because the anode is so made that it will prevent the loss of electrons. Thus, we get the one-way valve action of rectification; the electron flow (or the negative current flow, if you like to think of the normal current flowing from positive to negative) can move in but one direction through the tube —from cathode to anode.

But that is not all. In these days of commando tactics, we are taught that it is most effective to kick a guy when he is off balance, or sock him when he is not looking. In a similar manner, if we can catch the current passing from cathode to anode in its simplest state, as a stream of electrons, we can control it with the greatest of ease. For instance, the electrons in an ampere-second of current weigh about a billionth of an ounce, something a lot easier to push around with a small control power than even the smallest and lightest switch or contactor. The control element added to the electron tube for this purpose is called a "grid," which is usually a spiral or grate of fine wires placed between the cathode and the anode. If the grid is held at a negative potential, with respect to the cathode, it tends to repel the electrons passing by it on their way to the anode, thus cutting down the flow of current, or possibly preventing it altogether. So long as the grid is negative, it pushes the negative electrons away, and thus collects no electrons to itself. No electrons means no current, and no current—even with a large impressed voltage—means no power. And to be able to control current without the use of power is a neat job!

Of course, if we make the grid positive, it will assist the flow of electrons to the anode and a larger current will flow, but only at the expense of some electron current to the grid. With the grid negative we can have control power for next to nothing.

Types of Tubes

The electron tubes that are used in industry may be divided roughly into three groups: phototubes, high vacuum tubes, and gas filled tubes.

A phototube is rather unique. It is a simple two element rectifier in an evacuated glass bulb. The cathode is not heated to release the electrons, but is made of material which releases or emits electrons as light strikes it. These electrons can then be attracted as a small negative electric current to the positive anode. You might have guessed that the number of electrons which should be kicked out of the cathode material when light strikes a small cathode would not be very large; you would be quite right. We are lucky to get a millionth of an ampere, in most cases, and under certain conditions the current is much less. In fact, the output is so small that in order to make use of it, we must boost it up or amplify it with a pliotron or thyratron, in order to operate even the smallest practical relay or motor.

Phototubes are the "electric eyes" of industry. Responding to a shadow or a flash of light, they may be used to count people, food, freshly painted articles, and other things which it is not desirable to touch, as well as to perform many other simple switching applications. In more advanced equipments, they can check or compare colors, read high temperatures, and control very rapid and accurate movements through the weightless and wearless light beams. The potential uses of the phototube are limited only by man's imagination.

Vacuum tubes which are simple rectifiers, and which have but two principal elements — the electron emitting cathode and the collecting anode — are called kenotrons, or "diodes" ("di," indicating "two"). If we add one grid for the control of the electron stream, it becomes a "triode." All high vacuum tubes with one or more grids are called pliotrons, or simply, amplifier tubes. Sometimes they are referred to by their function, such as transmitters, oscillators, or converters. If more grids are added in the electron stream to control the flow, as series valves in a pipe, the tubes may be called tetrodes (four element, two grid), pentodes (five element, three grid), etc. The typical vacuum tube is a low current device which has a comparatively high voltage drop within the tube, yet it is capable of extremely fast and continuous control of the current with minimum grid power.

The pliotron is the familiar tube in radio receiving sets. Its role of amplifying a small signal or supplying a small output power is just as useful in industrial devices. Because of its characteristic of continuous control at extremely high frequencies, in the larger sizes it is used to supply the many kilowatts of power required for large broadcasting stations, or for induction and dielectric heating.

Gas filled tubes, if used as rectifiers only, are called phanotrons; if they contain control elements, they are called thyratrons or ignitrons.

A thyratron tube has a hot cathode to emit the necessary electrons, and a grid to prevent current flow when desired. However, it also contains mercury vapor, obtained from a drop or two of mercury in the tube, or it may contain inert gas, such as argon or xenon at low pressure. The gas or vapor helps to cut down the high internal voltage drop found in the pliotron. A constant voltage drop of about 15 volts is held for any value of current within the ability of the cathode to supply electrons. (This is done by a process called ionization.)

Because of this low drop, a thyratron of a particular size can be rated for a continuous current of 10 to 20 times that of a pliotron of the same physical size. Thyratron current ratings run into amperes; most of the pliotrons with which we deal will carry continuously only a few milliamperes.

But gas filling does have a few drawbacks. For instance, the maximum voltage of the controlled circuit is limited, but it is still well above the usual industrial control voltage range. Of more importance to us is the fact that the gas prevents the grid from controlling the current after the flow has once begun. In other words, a negative grid will prevent the flow of current as the anode is made positive; but once it has permitted the electron arc to start, it is powerless to stop it. The current can then stop only as the anode power is removed, or, in any a-c circuit, during the a-c voltage negative cycle. Even then, the deionization time required to regain control may

be approximately a millisecond; therefore, thyratrons do not operate at frequencies much greater than the commercial power frequencies.

The thyratron is the handyman of the industrial tubes. It controls motors, energizes magnetic contactors, and supplies small amounts of heat whenever accurate control or high speed operations are required. Operating indirectly, by controlling generator fields or saturable reactors, it can control large amounts of power — many hundred horsepower or many kilowatts—for heat or lighting.

The ignitron tube is similar to the thyratron in that it is a gas filled tube, but it differs in that its cathode is not heated to free the electrons. Instead, its cathode is a pool of mercury and its electron emitting energy is derived from the arc stream itself. This is a cumulative action—the larger the current the more electrons are made available. Thus, the instantaneous current capacity of the ignitron is limited only by the size of the elements and the leads to carry the heavy current. This may be hundreds of amperes. The continuous current rating is determined by the ability of the tube to dissipate the heat losses. The larger sizes of ignitrons have built-in water jackets through which cooling water is circulated.

Since the ignitron, unlike the thyratron, does not have electrons immediately available at a hot cathode, its control element, the "igniter"—a pointed piece of crystal dipping into the mercury pool —must actually "blast" a few electrons loose from the mercury to start the arc stream. This requires real power; as much as 40 amp at 200 volts, for a few microseconds. So it can be seen why the ignitron is most practical for high currents and large power requirements.

Ignitrons are the heavy artillery of the industrial tubes. They are called upon to control the hundreds of amperes required for resistance welding. They rectify and control the large amounts of power needed for the manufacture of aluminum, in electrochemical processes, and for steel mill and factory direct current shop voltages.

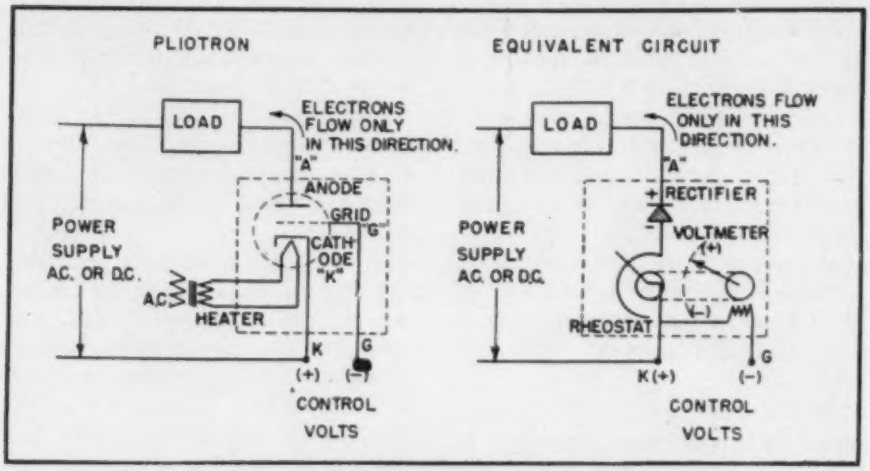


Fig. 1—Pliotron operation and control. Current is usually in milliamperes.

To sum up briefly: The phototube, using the energy of light to release electrons from its cathode, has so small an output in microamperes that a pliotron or thyratron must be used to amplify it to a useful value. The output of the pliotron (milliamperes) is sufficient to operate small relays, or to control a thyratron. Thyratrons, in turn, control amperes to operate large contactors, or motors in the usual control sizes from fractional horsepower up to 5 hp or more, or to control ignitrons. Ignitrons can handle hundreds of amperes, but require a reasonable amount of control power for operation.

How the Tubes Work

We said before that anyone who can understand a rectifier, a rheostat, and a voltmeter can understand tubes. Now we will prove it.

Take any kind of rectifier — copper-oxide or selenium—anything that will pass current in one direction and stop it in the other. Connect a rheostat in series and drive it by a voltmeter element, the positive terminal of which is connected to the negative terminal of the rheostat. Gear the rheostat to the voltmeter element in such a way that more negative voltage will cut in more resistance (see Fig. 1). The rheostat is stepless, and goes to infinite resistance or open circuit at the high end. It is assumed that the voltmeter and rheostat can move extremely fast, 100,000,000 times per second; and the voltmeter is of extremely high resistance, perhaps a megohm or more.

This simple circuit can be used to replace a triode pliotron in any industrial circuit, and will do ex-

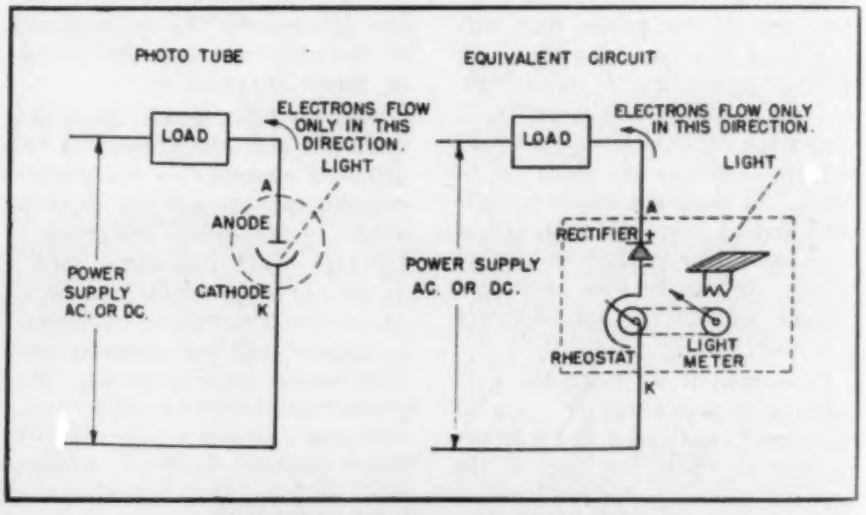


Fig. 2—Phototube operation and control. Light controls a flow of microamperes.

actly the same job. If the tube is a tetrode or pentode, other series rheostat - voltmeter combinations may replace each grid. Nothing particularly tough about this circuit, is there?

Would you like a phototube? Then simply replace the voltmeter with an exposure meter so that increased light on the sensitive surface will move the meter element to cut resistance out of the rheostat (see Fig. 2).

As for the thyratron and ignitron, they are no more complicated. In series with the rectifier we'll place a battery of about 15 volts and so connect it that it will be charged by the current which the rectifier permits to pass. (This corresponds to the constant arc drop of the thyratron for all current values.) Finally, in the circuit is a series relay that is connected to "seal in" or "lock in," when the circuit is completed through its own single, normally open contact. The relay armature is moved, and this contact is closed mechanically by the action of the control voltmeter (just as the rheostat turned, in the description of the pliotron). The contact moves to close as the voltage becomes less negative (see Fig. 3).

Once the contact has closed, however, the holding power of the series relay is so great that the small voltmeter torque is powerless to open it again until the current has stopped flowing.

The ignitron equivalent is about the same, except that we must remember that we are dealing with larger power, and the size of everything becomes larger. In place of the voltmeter, we can use a small solenoid. A rectifier in series with the solenoid, to permit current to flow in but one direction, may not be necessary in our electromechanical picture, but it is necessary in the ignitron circuit to prevent injury to the igniter by reverse current, so we'll put it in to make our picture complete (see Fig. 4).

And that completes our one-lesson course on the industrial electron tube. We do admit that a few of the details, about as essential as trouser cuffs and pocket flaps, have been omitted. But the fundamental facts are here.

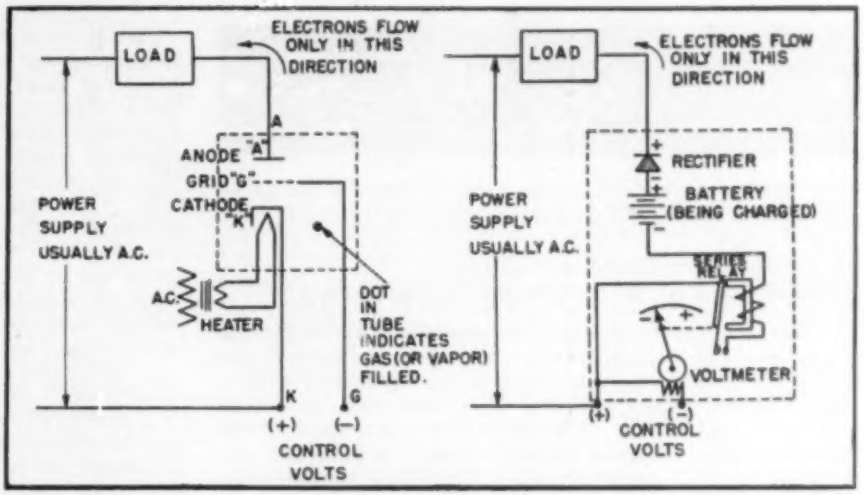


Fig. 3.—Thyratron operation and control. Current rating is usually in amperes.

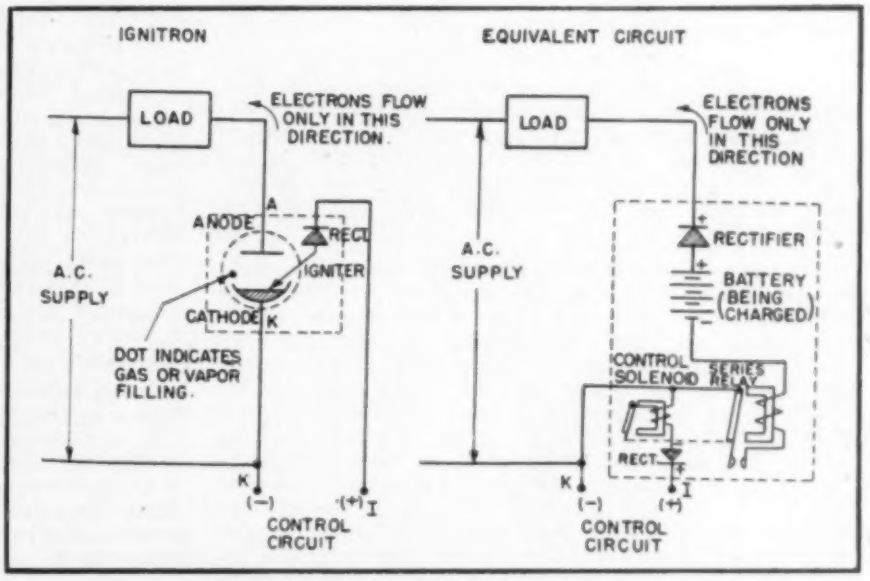


Fig. 4—Ignitron operation and control. Current may be hundreds of amperes.

Viscosity of Steam and Air

A READER of HPAC recently asked for information on the viscosity of steam and of air in a vacuum. Following is an answer:

The viscosity of a permanent gas such as air is practically independent of the pressure. The big change in viscosity occurs only with change in temperature. Consequently, Fig. 3 on p. 463 of the September 1943 HPAC, which gives the viscosity of air at various temperatures, can be used regardless of the pressure or vacuum.

For steam, the situation is almost the same as for air. The curve of zero gage pressure steam on the same page can be used with very little error for the curve of zero absolute pressure. This can be verified by referring to Fig. 16 on p. 25 of the ASME publication, Flow Measurement—1940, where a curve for zero absolute pressure is given.

WPB . . . OPA . . . PAW . . . Etc.

[Also see pp. 10, 34, and 38 in main editorial section, and p. 206 in back section.]

Amended L-38 Order Simplifies Procurement of Air Conditioning Equipment

After an eight-month ban on production of mechanical water coolers, manufacturers of such equipment are now permitted again to produce these units for industrial uses, according to limitation order L-38, as amended, issued December 6 by the War Production Board. In addition, the amended order simplifies the procurement of industrial and commercial refrigerating and air conditioning machinery and equipment.

The amended order provides a more flexible basis for production. It eliminates insulation materials, whether or not incorporated in insulated enclosures and cold storage doors, from the provisions of the orders. Coils, or "low sides" that are incorporated into food processing machinery as defined in limitation order L-292, are now eliminated from the restrictions of L-38.

Where reference is made to "for direct use by the Army, Navy, Maritime Commission, or War Shipping Administration," this term now includes military exchanges or service departments under priorities regulation No. 17. This is a departure from the previous order, which required that the delivery of equipment for military exchanges and service departments be subject to the same restrictions as civilian deliveries.

The revised order provides that no person shall deliver and no person shall accept delivery of any new system or new parts except pursuant to an approved order, which may now be any order placed in accordance with any CMP regulation or any preference rating order, any order approved on form WPB 2448 or 2449, or any order for the direct use by the Army, Navy, Maritime Commission, or War Shipping Administration. This provision does not relax any of the present restrictions on the essential uses for which refrigeration and air conditioning equipment may be delivered, but merely provides for the use of existing CMP regulations and preference rating orders, the use of which will eliminate a considerable number of the applications now received by the WPB for the smaller equipment. There is a provision also that no person shall deliver new systems or parts to any person except on an order bearing a rating of AA-5 or higher. This means that deliveries from one manufacturer to another or from a manufacturer to a dealer or distributor or by a dealer to the ultimate consumer can only be made on an order bearing a rating of AA-5 or higher. Formerly, the delivery of equipment by a manufacturer to a dealer or distributor was permitted on an unrated order.

Five additional items have been added to list A, the delivery of which may be made unrestricted, but the production of such items is prohibited for any purpose. The new items added to list A are as follows:

Drinking water coolers, non-mechanical.

Drinking water coolers, mechanical, bottle type.

Drinking water coolers, mechanical, pressure type, capacity less than 5 gph, 80 to 50 F with 80 F ambient temperature.

Self-contained air conditioning units, 2 hp or less.

Wall type display cases, refrigerated.

Although items on list A may no longer be produced, the revised order does permit the assembly of any list A item if 75 per cent (by weight) of the total material to be incorporated in the item was fabricated and in the producer's inventory prior to April 6, 1943, and the material cannot be used in the assembly of any system or parts not shown on list A.

List B (items that may be delivered to specified users and for special uses) has been revised so that any of the permitted users may assign a rating of AA-5 for the delivery of any of this equipment by a certification in accordance with priorities regulation 3 unless the orders are otherwise rated. Delivery of items on list B to other persons may be permitted if they receive an approved order on form WPB 2448 or 2449. Under list B mechanical drinking water coolers, pressure type, capacity 5 gph and over, may now be delivered without special authorization for direct use by the Army, Navy, Maritime Commission, War Shipping Administration, hospitals, petroleum operators as defined in order P-98-b, or industrial plants (excluding offices, rest rooms, and recreation rooms) manufacturing any product or conducting any business or activity listed on schedule 1 of CMP regulation 5. Refrigeration systems for farm milk coolers have also been added to list B and may be delivered for direct use by any person who has a purchase certificate from a county farm rationing committee and also to any producer of farm milk coolers operating under orders L-257 or L-257-a. Other changes on list B include permitted delivery of mortuary refrigerators to institutions and hospitals and the permitted delivery of portable bulk ice makers for the direct use by the Maritime Commission and War Shipping Administration. Items on list B may be produced in accordance with the production provisions of paragraph (h) of the order.

To eliminate the necessity of the applicant filing both a form WPB 2448 or 2449 and a WPB 617 where construction is involved, the revised order provides that where the cost of construction (exclusive of the cost of the prime mover, compressor, condenser, receiver, evaporator surface, controls, indirect cooling units, and cooling towers) is more than $5000, the applicant shall apply for the whole project, including the refrigeration or air conditioning system, on form WPB 617. Where the cost of construction is less than $5000, the system shall be applied for on form WPB 2448 or 2449 and if authorization is granted it will be accompanied by any necessary permission to "begin construction" under conservation order L-41 and no separate application on WPB 617 need be made.

As the revised order requires a rating of AA-5 or higher for the delivery of any equipment, forms WPB 541 or WPB 547 may be used by dealers or others who are not producers and who are purchasing for inventory or resale. If the dealer or other person is at present using form WPB 547 to obtain ratings for equipment and parts, it is recommended that he continue to use this form in applying for refrigeration equipment and parts for inventory.

A new provision of the order provides that form WPB 541 may be used where the applicant desires to export or acquire for export any systems or parts. However, delivery of items by the exporter is subject to the restrictions of list C (essential uses).

The production restrictions of the order have been revised so as to provide a greater flexibility of production and to provide a means for producers to begin the production of restricted refrigeration equipment as materials become available. After a minimum production has been established, the demands will regulate the production by the number of approved orders and the amount of critical materials available. Beginning January 1, 1944, and during each later calendar quarter, no producer shall manufacture or assemble more of any class of new systems and parts as shown on list D than his quota for that class. This is exclusive of repair and maintenance parts. The quota for any class is in terms of aggregate dollar volume and may be the greater of the following two quantities:

1) The dollar volume of all unfilled orders on hand rated AA-5 or higher for that class of new systems and parts, or

2) One-sixteenth of the aggregate dollar volume of that class of new systems and parts (other than items on list A) manufactured by him during the calendar year of 1940, in addition to his current production required to fill all orders for direct use by the Army, Navy, Maritime Commission, or War Shipping Administration.

Change in MPR 165 Affects Air Conditioning Maintenance

So that there may be an adequate supply of repair and maintenance services for mechanical, electrical, and gas equipment and appliances used in the home, in hospitals, hotels, schools, and business places, the Office of Price Administration last month issued a regulation that enables some suppliers to increase their prices—supplementary service regulation No. 22 to maximum price regulation No. 165.

In normal times a great deal of such service is rendered at or below cost as an accommodation to customers, in order to build good will leading to purchases of new equipment from the supplier, OPA said. In other instances, repair and maintenance is the chief feature of the supplier's business, but increases in labor costs for skilled mechanics since March 1942 call for adjustment of customers' prices if suppliers are to be able to continue in business. Ceiling prices at March 1942 levels, which have obtained until now, do not take into account either of these circumstances.

The regulation enables suppliers who charge on the basis of a customer's hourly rate, to continue charging at their highest March 1942 prices if they choose but offers alternate methods of determining ceiling prices.

A supplier of the services who employs mechanics may now choose one of four ways for use in establishing his maximum hourly charges to the customer. The four methods are:

1) Charge the highest customer's hourly rate that the seller charged in March 1942.

2) Charge the customer for each hour of service a price that is double the average basic hourly wage rate paid on October 3, 1942, to employees performing the particular type of service.

3) Charge the customer 60 cents more per hour of service than the average basic hourly wage rate paid on October 3, 1942, to employees performing the particular type of service.

4) If the supplier employs no more than eight employees, and is exempt from wage control by the National War Labor Board, add to the customer's hourly rate determined under either 2 or 3 above, an amount equal to the increase since October 3, 1942, in the average straight-time hourly rate for mechanics performing each type of service. (A price established on this basis may not be changed oftener than once in 30 days.)

A person who does not have any employees may use either one of two methods to determine his charges, as follows:

He may charge the highest hourly rate that he charged in March 1942 for the same service to a purchaser of the same class, or

He may charge the maximum hourly rate that is charged by his most closely competitive seller who does employ mechanics to perform the service.

The regulation affects electric fans, lamps, refrigerators, refrigerating equipment up to 25 hp, air conditioners up to 25 tons capacity, sewing machines, vacuum cleaners, washing and ironing machines, kitchen equipment and appliances, radios and phonographs, and similar articles. It does not, however, include gas unit heaters, furnaces, industrial equipment, water heaters, oil burners, typewriters, adding machines, dictating machines, duplicating or other office equipment.

MPR 165 Supplement Allows for Extra Cost of Overtime Repairs

Two methods that may be used by service shops in the various repair trades in setting charges to customers to offset increased costs resulting from the payment of overtime wage rates were outlined last month by the Office of Price Administration with the issuance of supplementary service regulation No. 21 to maximum price regulation No. 165.

They apply to all suppliers of services whose prices are based on an hourly charge to customers for labor under the terms of the services regulation (No. 165).

This action was made necessary, OPA said, because of the

• WPB . . . OPA . . . PAW . . . Etc. •

decided trend in the repair business toward a lengthening of the work week and the payment of overtime wages beyond the first 40 hours. The 48 hr week has been made mandatory in many areas by rulings of the War Manpower Commission. In many other cases it has been adopted voluntarily in order to use available workers more efficiently. Charges for most repair services were frozen generally at the March 1942 level. In authorizing an increase in customers' rates where overtime service is provided, OPA has recognized the problem that added overtime costs have imposed upon many establishments.

A choice of two pricing methods is now allowed to shops with mechanics working 48 hr a week who are paid at overtime rates for the last 8 hr.

First, an additional charge is permitted for work done in overtime hours, which may bear the same ratio to the regular hourly charge that the overtime wage rate bears to the regular wage rate, providing the customer requests this overtime service and is willing to pay extra for it. Thus, if a shop pays time and half for overtime it may charge 1½ times its regular charge for work done in overtime hours, providing this is agreeable to the customer. Under the same conditions, if it pays double time for overtime, it may charge double the regular hourly rate for overtime work.

Under the second method, an upward adjustment of the regular customer's hourly charge may be made in an amount that approximately represents the additional overtime cost. Where this method is used, all jobs are priced on the same basis during the full 48 hr of the work week, and each customer, by paying slightly higher prices, absorbs his share of the extra cost. The amounts that may be added are as follows:

Where overtime is paid for at 1½ times the regular rate, shops with customers' hourly charges under $1.75, may increase the hourly rate by 5c. Those whose hourly charges range from $1.75 to $3.49 may increase the hourly rate by 10c. Those whose hourly charges are $3.50 or more may increase the hourly rate by 15c.

In exceptional cases, where the 8 hr of overtime are paid for at double the regular rate, permissible increases are 10 cents on hourly charges below $1.75, 20 cents on charges from $1.75 to $3.49, and 30 cents on charges of $3.50 or more.

Hard Coal Deliveries to Users Limited by SFA

Solid Fuels Administrator for War Harold L. Ickes announced December 15, that because of the anthracite production deficit it has been necessary to limit deliveries of hard coal to domestic users to not more than seven-eighths of their anticipated requirements for the coal year ending March 31, 1944, and to increase the amount of bituminous coal available to them.

The limitation upon deliveries was made necessary because of production losses due to mine strikes and the overall inability of the hard coal mines to expand output enough to meet growing wartime coal needs. Previous regulations controlling shipments to dealers, and for spreading dealers' deliveries among consumers are not changed.

Administrator Ickes said that the Solid Fuels Administration, in order to prevent undue hardship, is preparing to divert more bituminous coal to retail anthracite dealers who lack sufficient hard coal to supply the essential needs of their customers. He pointed out that if all users conserve their fuel to the utmost, the amount of domestic anthracite and bituminous coal that can be made available to hard coal users should be sufficient for minimum domestic heating needs provided that the anticipated supply is not further cut by work stoppages or other emergencies.

Women in White Collar Jobs

The women who are doing men's work in the air conditioning industry are not all in overalls. Much attention has been given to the women on production lines, but there are many office, technical, and other "white collar" jobs formerly done by men and now done by women.

The wartime change-over to women workers in Carrier Corp. to order clerks, draftsmen, expeditors, and other positions is no doubt typical of what has taken place throughout the air conditioning, refrigerating, and industrial heating industry. Here are a few examples of what the women are doing to keep things going and release men for other war duties.

The company is proud of its efforts toward winning the war, proud of its men in the armed services (numbering about 500), and glad to have an opportunity to tell of the part the women are doing on the home front to "Get it over quick."

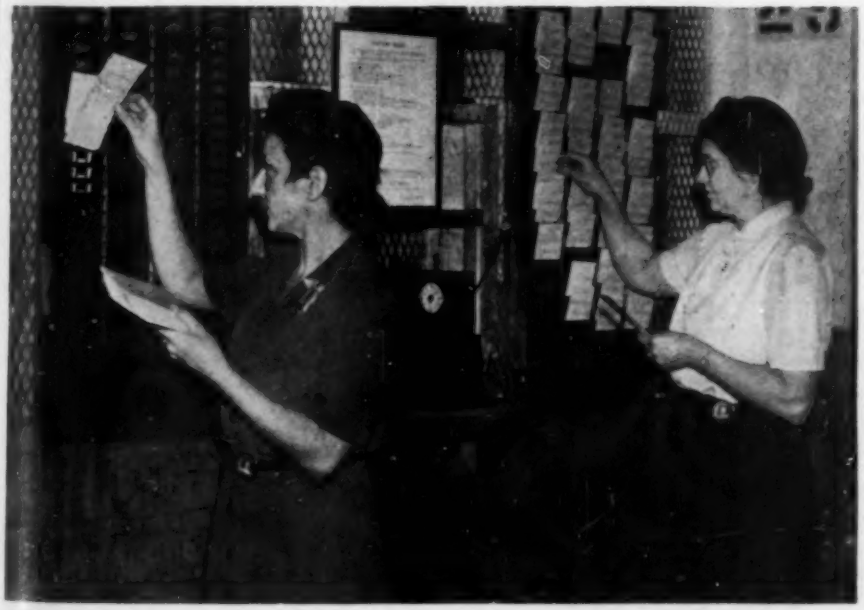
—Margaret Ingels, engineering editor, Carrier Corp.

Women guards were added to the staff as wartime operation required an increase in number of guards and men who could qualify were not available to fill the positions. The three guards are Mrs. Frances Copeland, Miss Jeannette Schneider, and Miss Isobelle Ross. Two have daytime shifts and one the night shift. They are given courses in plant protection, first aid, and fire prevention as a part of the training for the work

The product information department prior to the war was staffed entirely by men. At the present, two women are employed in the department. One is Miss Nancy Collins, doing the work formerly done by an engineer student released to become a radio operator and tail gunner in bomber service. Her work consists of making drawings of equipment and curves used in technical publications. Another woman worker in the department is Mrs. Ruby Bigelow, a former teacher and secretary. A graduate of Syracuse University, Mrs. Bigelow is making up pages for instruction manuals and other publications. Her brother, an Army bombardier, is reported a prisoner of war

Women draftsmen in wartime start in the development department, usually making the simplest of tracings, and gradually work up to junior draftsmen. Ruth Alice Graves joined the company only six months ago and though she started in the usual way, her progress has not been gradual. Already she is doing the work considered a "man's size job," and is filling a position formerly held by a man who is now serving in the Navy

When a student chemist was needed in the development department, Miss Rose Fallico, who was working in the drafting room, was given the position. She is taking an extension course at Syracuse University, studying chemistry and English to better qualify herself for scientific work. The expansion of the research program and the shortage of available men student chemists gave Miss Fallico a chance she might not have had in peacetime



Timekeepers prior to the war were men, but now three women are doing the work. Mrs. Hilda Krauss began the work a year ago when a new department was formed to make a special airplane part. Mrs. Alta Belcher, who has a son in the Army, took the place of a man timekeeper who was transferred to the shop to fill a vacancy made by a man joining the Army. Mrs. Belcher is truly a war worker, as the only times she has been employed were during World War I and at present. Miss Iva Collins, a third timekeeper not in the picture, replaced a man now in the Army

"OPEN for DISCUSSION"

Decentralized or Centralized Air Conditioning Systems?

Tonnage and Horsepower Requirements

THE EDITOR:

The comments by W. A. Grant in the Open for Discussion columns of the November issue, to the effect that the choice of decentralized or centralized air conditioning systems boils down to a question of expediency does not impress me. In my 30 years of consulting engineering work it has always been my slant on engineering installations that simplicity should be paramount. The simplest installation is always the lowest in first cost and will also give the lowest operating cost.

In Mr. Grant's paper on Air Conditioning of Blackout Plants, published in the 1942 ASHVE Transactions, he said, regarding the first half of the Long Beach Douglas plant: "The total project includes 23 boiler rooms and 68 self-contained direct expansion air conditioning and refrigerating systems averaging 60 tons, for a combined total of 4026 tons of refrigeration. Such extensive complication has not been found necessary in most other large projects that are fully air conditioned."

I believe that such an offhand statement can best be answered by the accompanying tabulation that H. M. Hendrickson has prepared of two plants having a comparable total of installed refrigeration tonnage. This table lists the horsepower of the auxiliary equipment required to develop and deliver the final useful output at the point of use, at the cooling and heating coils.

In both plants the ultimate job is to deliver the final product—cooled or heated air—to the working spaces of the manufacturing and office buildings. You will note that to get the final refrigerating effect to the cooling coils of the fan stations serving the working spaces requires auxiliary horsepower of 45.2 per cent for the central plant, employing the large centrifugal refrigeration units and chilled water for distribution, as compared to the decentralized job with direct expansion units at the fan stations of 10.2 per cent.

My personal opinion is that these percentages give the real comparison between the two types of installations. Why use a lot of extra auxiliary power to do the job if you can get a simple installation that does not require this extra power? Frankly, I believe that it would be well to apply this same method of comparison to all types of air conditioning installations.

It is my opinion that the modern boiler plant which operates at high pressures and high ratings with all its concomittant auxiliaries such as induced and forced draft, high pressure boiler feed pumps, precision combustion controls, boiler feedwater softening equipment with necessary chemical controls, continuous blowdown equipment, etc., involves much greater complication than the mere repetition of standard refrigeration compressors with adjacent evaporative condensers at each fan station. I have been called in on plants where the boilers operate at high pressure and high rating where the chemical control of boiler feedwater alone is a very exacting day-in and day-out job.

When we started the initial plans for the Long Beach plant the various possible ways of doing the job were carefully considered. The possibilities of central compressor and boiler plants for each building in the group were also considered and were explored by making diagrammed piping layouts and then figuring sizes and costs of the extensive piping systems involved. This process gradually boiled the job down to the close-coupled unitary design as installed.

I for one believe that the elimination of miles of pipe lines involving expansion joints, special

Comparison of Central Station and Decentralized Air Conditioning Systems in Two Blackout Aircraft Factories

	Central Station	*Decentralized*
Total tons refrig.	7000*	7693**
Refrig. machine hp	6962 (Steam turbine)	7061 (Electric)
Hp per ton refrig.	0.995	0.92
Aux. refrig. hp		
Evap. cond. or cooling tower fans	540 (Electric)	645 (Electric)
Evap. cond. or cooling tower pumps	460 (Electric)	76 (Electric)
Chilled and hot water circ. pumps	1215 (Electric)	0
Boiler induced and forced draft fans	495 (Steam turbine)	0
Boiler feed pumps	360 (Steam turbine)	0
Cond. return pumps from turbines	42.5 (Electric)	0
Chem. pump boiler treatment	0.5 (Electric)	0
Water filter pump	1.0 (Electric)	0
Boiler chem. pump	1.5 (Electric)	0
Boiler sludge pump	1.0 (Electric)	0
Boiler vac. cond. pumps	20.0 (Electric)	0
Boiler controls air comp.	4.0 (Electric)	0
Air cond. controls air comp.	5.0 (Electric)	0***
Total refrig. aux. hp	3145.5	721
Total refrig. hp incl. aux.	10,107.5	7782
Hp per ton refrig. incl. aux.	1.44	1.01
Ratio aux. hp to refrig. mach. hp	45.2%	10.2%
Additional aux. hp for heating only		
Cond. ret. pumps	30 (Electric)	58 (Electric)
Hot water circ. pumps for booster heaters	65 (Electric)	0
Total connected hp for heating and cooling	10,202.5	7840

*Rated tonnage of water cooling systems when cooling 14,000 gpm from 59 F to 47 F.
**Rated tonnage of refrigeration systems operating at approx. 45 F evaporator and 105 F condensing temperatures (direct exp.).
***Auxiliary air for control systems furnished from main plant compressed air system through reducing valves.

roller supports and many sectionalizing valves is certainly getting away from "complication" rather than embracing it.

The central refrigeration and boiler plant requires a large and structurally husky building to house it. Such a building, with a very large adjacent cooling tower, certainly does not compare favorably in either first cost or the floor space required with the small lean-to boiler rooms and the platform space added to the fan station platforms above the bottom chords of the roof trusses to accommodate the refrigeration compressor-condenser combinations of a unitary installation such as is used at Long Beach.

In conclusion, I am inclined to believe that a study of the tabulation of equipment involved in the two basic designs will give the answer more clearly than words as to which involves the greater "complication."—O. W. OTT, consulting engineer.

Use Discretion in Making Postwar Construction Plans

New School Buildings Needed

THE EDITOR:

There is a question of the wisdom in planning today too far in advance. There was a time when one could plan for many years ahead and feel reasonably sure the plans that were made would fit the need when their use arose; however, war always accelerates change and developments forced upon us by necessity make planning too far into the future unwise. The world is going through one of those periods at this time with practices and concepts changing so rapidly, that today is little like yesterday—nor will tomorrow be like today. How often have we seen a family plan their dream house of the future that at the time of planning seemed to them to be perfection, yet when the time came a few years later when they could build the house they found that their ideas had changed, that what was perfection when planned a few years earlier had become outmoded and no longer desirable?

While of course certain basic ideas in building will remain, the future market will offer so much that is new it is dangerous today to plan future construction in detail. The promotion that has been given the thought of fuel conservation in the past two years, for example, is certain to have an influence upon building construction. A construction that will provide an adequate barrier against heat transfer from the inside to the outside in winter and from the outside to the inside in summer will be a necessity in future buildings. It is possible that industrial research will develop building construction materials that will in themselves contain all the elements of physical strength, weather resistance, and insulating properties, making the provision of separate insulation on the inside of the building construction proper unnecessary. The shortage of help will make people conscious of the need of streamlining and simplifying in order to make buildings more efficient from the standpoint of man-hours required in their operation and maintenance. This will make possible in most cases a smaller building to serve the needs of the family or the industrial plant, which in turn will mean a smaller investment in plant equipment and such services as heating, ventilating, lighting, and air conditioning. The yardstick of efficiency may modify many building designs.

Those who plan for the expansion of an industrial plant, say three years from today, have an even more difficult problem than do those who are planning a home three years ahead, for the same forces that will bring about changes in building construction will bring about changes in what will be needed in the future. This will in turn make it difficult for a manufacturer to plan on what he may be called upon to produce. It is therefore dangerous for him to make too definite plans for his plant expansion far in advance.

However, there is a certain amount of postwar planning that can be done now which, if the need justifies, can be changed before actual construction contracts are awarded; as soon as the rush of war plant planning and construction is over the architect and engineering forces in drafting rooms may well be utilized in such planning.

It is generally thought much of the building construction in the postwar period will be government inspired. The picture in most of the large cities is pretty much the same. Munitions or war plants have been built generally outside of the large metropolitan areas because of the need for protection against disaster. While the postwar period will bring about a tremendous deflation in the inventory of these plants throughout the nation and many of necessity must be abandoned, there will still be many that are of a permanent type of construction and that will be operated as industrial peacetime plants. When employees in such plants feel there is a permanency to their employment they will seek housing facilities convenient to their work. This will bring about a postwar building of new homes and shopping centers outside the metropolitan areas, probably privately financed.

Building projects in the large cities will be generally government sponsored and will include bridges,

HPAC's readers and editors will welcome your comment on articles or parts of articles published in these pages, and on other topics of interest to those concerned with design, installation, operation, and maintenance of heating, piping, and air conditioning systems in industrial plants, commercial, institutional, and public buildings. Address The Editor, Heating, Piping & Air Conditioning, 6 North Michigan Avenue, Chicago 2, Illinois . . . This month, further comment on the relative advantages and disadvantages of centralizing or decentralizing large air conditioning systems is presented. Various viewpoints on planning now for the postwar construction of plants and buildings are also given.

sewer systems, highways, and of course public buildings. The large cities seem to have arrived at a point where many of them are having very little normal growth so that public school buildings that will be built under such a public works program will be for the purpose of replacing old, obsolete buildings or for modernizing existing buildings. A school building survey in most of the large cities will show a considerable number of buildings in each city that are over 50 years old and are obsolete when measured by modern school building construction standards. The shifting population in every city, too, leaves many old buildings standing in communities that have moved away so they are too big for the present needs of the community. A postwar program in these cases could well include the replacement of old, obsolete school houses with new buildings of a smaller size that would fit the decreased needs of the community—but, nevertheless, buildings that incorporate all of the modern ideas of school construction for a modern school program. This will reduce the operating and maintenance costs of the school systems and will give the children of every community an equal opportunity for training in a clean, wholesome school environment that will add to their health and safety. Plans for such a sensible program should be made now.—JOHN HOWATT, chief engineer, Chicago board of education; member of HPAC's board of consulting and contributing editors.

Must Have Definite Objective for Making Postwar Construction Plans

Great Need for Very Careful Analysis

THE EDITOR:

There can be no question as to the value of careful planning now for postwar construction, expansion, modernization, conversion, and repair of all types of industrial, commercial, institutional, and public projects. Each individual business firm must investigate its own future program and not lean on the government, chamber of commerce, or any other organization to do it.

Of course, general policy-making can be developed and guided by these larger groups, but each specific job must be carefully worked out by those who are immediately responsible for it and who will pay for its cost and benefit by its use.

The extent to which definite plans can be outlined at this time depends entirely upon the judgment of the people responsible for estimating future needs. Plans can only be made intelligently after there is a fixed and definite objective ahead. The hard part of the whole proposition is to determine the size and character of each project to be undertaken. As soon as this is determined plans should be prepared and studied with care, leaving as much latitude as possible for variations to meet unforeseen conditions which may arise by the time the war is ended.

It seems easier to plan for municipal and public improvements than for individual manufacturing processes because many of these are very fluid at the present time. Research, postwar market conditions, labor, taxes, and availability and price of various materials are all such uncertain factors. There has never been a time when management was faced with so great a need for careful analysis and wise planning for the future of industry.—LEE P. HYNES, Hynes Electric Heating Co.; member of HPAC's board of consulting and contributing editors.

State Institutions Represent a Fertile Postwar Planning Field

Don't Neglect Air Conditioning

THE EDITOR:

State institutional plants should be a fertile field for postwar planning of new building construction and the modernizing of existing heating and air conditioning systems.

Educational institutions anticipate a rapid increase in enrollment after the war. State hospitals will require extensions and rehabilitation. Since institutions of this class are dependent upon state appropriations, it is doubtful whether completely detailed plans and specifications should be carried out too far in advance, but preliminary plans and estimates will be needed as a basis on which to make appropriation allotments. Many state administrations already have appointed planning boards and others will undoubtedly do so.

In the opinion of the writer, plans for new buildings should include provision for complete air conditioning systems, for at least certain rooms. Too frequently in the past, the importance of space increase together with a limitation of available funds, has resulted in eliminating all but the bare essentials of heating and ventilation. Once a building has been completed, it is often impossible (and usually very expensive) to later install additional air conditioning equipment that will give satisfactory results, unless provision for such equipment has been included in the original plans. Nevertheless, certain rooms or groups of rooms in most buildings can be improved, and it seems to me that postwar planning in the air conditioning field should certainly include many state institutional buildings. This field has too often been neglected.—R. S. HAWLEY, chairman of the department of mechanical engineering, University of Michigan; member of HPAC's board of consulting and contributing editors.

"We shape our buildings and afterward our buildings shape us."
—Winston Churchill

We Save Heating Dollars by Steam Trap Testing, Repair

L. O. Adams, director of buildings and grounds at the University of Louisville, tells here why steam traps that are not functioning properly waste heating dollars and cause poor heating. He describes the method used for routine testing and repair of steam traps—and explains the testing and repair procedures, which pay dividends by reducing waste from traps blowing steam, improve the heating, and cut down the number of repair calls in winter.

THE FUNCTIONS of the steam trap —discharge of water of condensation and closing off against steam —are generally well understood. Operators frequently overlook, however, the necessity of periodic testing of traps to be sure these functions are being carried out. Failure to discharge water of condensation will, in the case of a radiator trap, cause a reduction in heat output from the radiator. In the case of a trap on a main, the results may be poor circulation of steam, hammering, and fracture of fittings. Failure to close off against steam results in waste from unnecessarily high return temperatures and in poor circulation because of loss of vacuum.

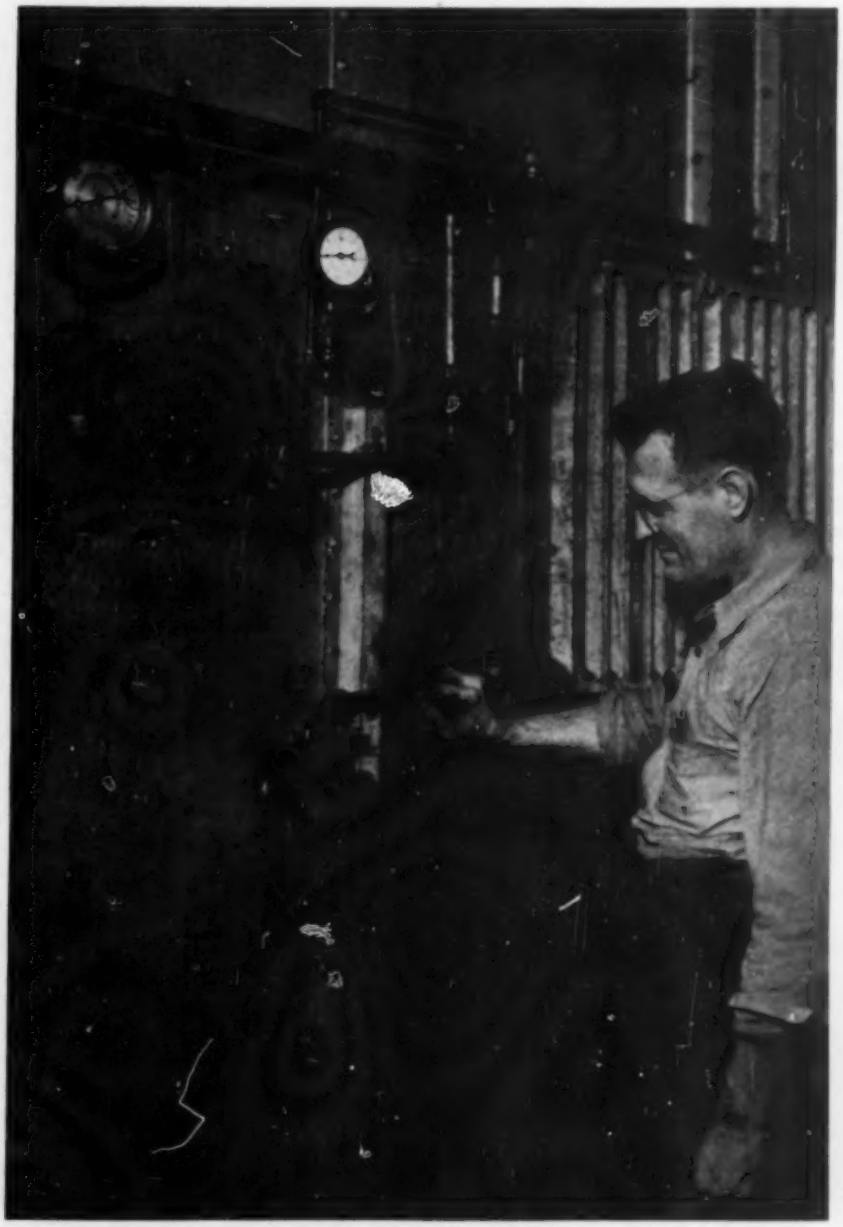
Routine testing and repair of steam traps at the University of Louisville has saved many heating dollars. The proper time to test traps is when the heating system is not in use. Traps can then be removed and tested on a rig similar to that shown in the illustration.

The lower left connection to the radiator is for testing the trap for proper discharge of water. On the left end the gage glass provides a visible indication that there is water in the radiator and whether the trap is holding back water. At the upper left end is the connection for testing the trap for closing off against steam. Steam is admitted to the radiator at the upper right end. The steam gage, connected at the upper left, indicates the pressure in the radiator.

In our testing routine, a trap which fails to function properly—either by holding back water or by failure to close against steam—is opened up and flushed out to remove scale and mud and is then retested. If it still holds back water, the bellows has stretched and is no longer able to open and a new bellows is installed. If the trap properly discharges water but continues to blow steam it is a sign the seat is scored or the bellows has failed.

If the seat is scored it is ground in. If the seat is not scored an attempt is made to reduce the travel of the bellows by removing the stem on the end and inserting a washer between the stem and the bellows. This decreases the distance of travel of the bellows to cause closure. If this procedure fails and the trap still passes steam a new bellows is installed.

This testing and repair routine pays dividends by reducing waste from traps blowing steam, by improving heating, and by cutting down repair calls in winter.



What 500 Installations Have Revealed About Radiant Heating

Charles A. Hawk, Jr., of the engineering service department of the A. M. Byers Co., has analyzed some 500 installations of radiant heating and studied many of them in the field. From this great amount of information, he has summarized the practical pointers given here on pipe coil layout, floor construction, insulating against downward heat flow, venting and draining pipe coils, temperature control, etc. Thus, his role is that of a reporter presenting the actual practice of a variety of engineers and contractors. The wide interest in radiant heating as an established wartime, and a promising postwar, method—and in the type of information given by Mr. Hawk—is demonstrated by the enthusiasm with which he has been received when speaking on the subject recently before engineering gatherings in a number of cities

IN ORDER that we may proceed from a common starting point, suppose we begin with an accurate understanding of exactly what radiant heating is. Reams and reams have been written to describe radiant heating, but in the final analysis it is nothing more than a system of producing comfort conditions by means of large, warm, room surface areas instead of depending on the movement of relatively high temperature air currents.

In a radiant heating system the temperatures of the cold room surfaces—such as outside walls, ceilings, etc.—are raised—either directly or by re-radiation—and thus the body's radiant heat loss is held at a comfortable level. The importance of this method of approach to the comfort problem is obvious when you consider that the major portion of the heat dissipated from the body is in the form of radiation loss—something in the neighborhood of 50 to 60 per cent of the total heat given off. This simply means that once an accurate control is established over the radiating factor, the comfort problem is near to being solved.

This basic fact is absolutely necessary to an understanding of the principles of radiant heating and is the major reason for the tremendous enthusiasm of those people who live or work in a radiant heated space. You see, these people become used to conditions in which the heating system behaves much the same as the re-radiation of electric lights. It produces a sensation of gentle warmth such as that experienced on a bright spring day—there is no sensation of stuffiness, "cooked" air, or drafts.

Coils May Be in Floor, Walls, or Ceiling

Experience seems to indicate that the simplest and easiest method of accomplishing this is to place pipe coils or grids in the floor and pass hot water through the pipes. The pipe runs may, of course, be placed in the walls or ceilings but we have come to feel that the floor type system is the first choice with the ceiling coil in the position of second choice and wall coils only in a supplementary capacity to either of these. For this reason, I shall confine my comments to the floor type system.

In a structural sense the floor type radiant heating system is exactly the same as the conventional forced hot water system except that pipe coils are substituted for radiators. The same boilers, expansion tanks, circulators, etc., are used, and you may safely consider the integration of these elements to be exactly the same for the radiant heating system as for the conventional hot water system.

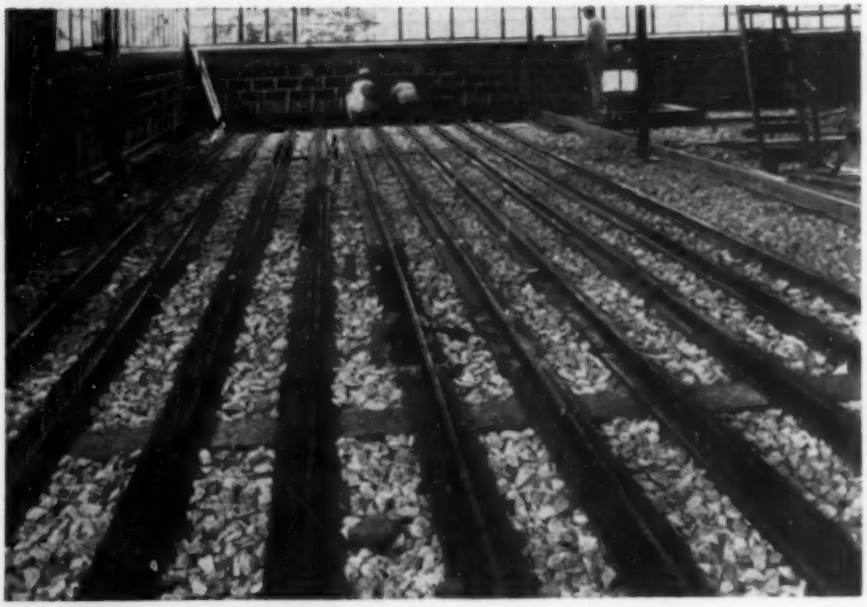
Calculating Radiant Systems

The matter of calculation for a radiant heating system is not as intricate as you might believe. The principles are firmly established and begin, naturally, with an accurate calculation of heat loss from the space under consideration. The Heating, Ventilating and Air Conditioning Guide, published by the American Society of Heating and Ventilating Engineers, covers this type of calculation very thoroughly. The difference in calculation for a conventional system and a radiant system occurs when you begin the calculation of heat input to balance this loss and here's the fundamental trick: For a conventional system you're used to thinking of output from equipment such as radiators only in terms of losses to air at a given temperature. In a radiant system, two kinds of losses or output from the warmed surfaces are considered—the losses by radiation to the cooler room surfaces and the loss by convection to the air.

Floor Construction

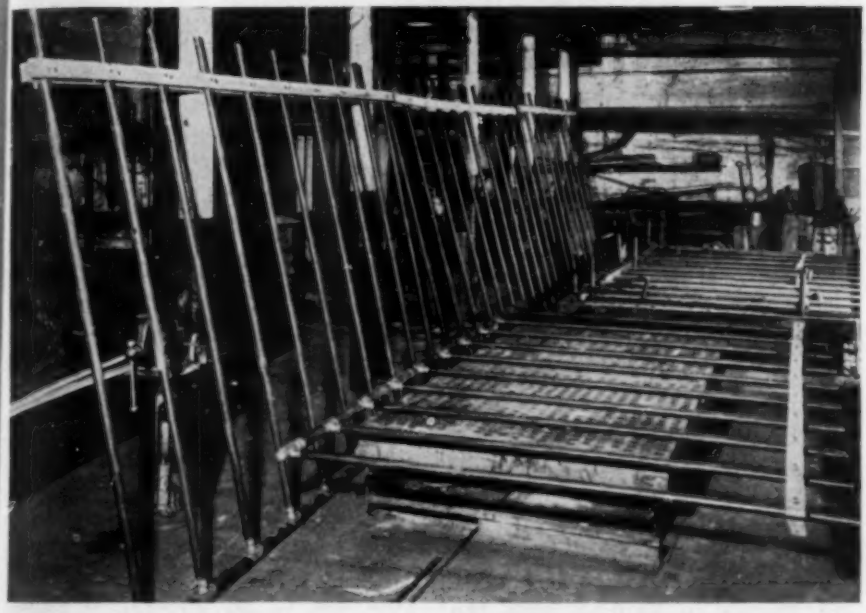
After calculations have determined the physical characteristics of any particular radiant heating system, the next problem is to integrate the pipe coils or grids into the structure being planned. Most of the radiant systems which have been used in this country have incorporated heating coils in concrete slabs which may or may not be on the ground. The thickness of the slab is of no great consequence since there is ample evidence to prove that the system works equally well with slabs ranging from 3 to 8 in. or 10 in. The pipe coils may be either encased within the concrete, in contact with the lower surface, or several inches below, embedded in gravel or crushed stone.

At this point I should like to drop a word of warning about slab



Grid type coils supply the heat for a plant addition near Baltimore; both the supply and return manifolds for these pipe grids were shop fabricated

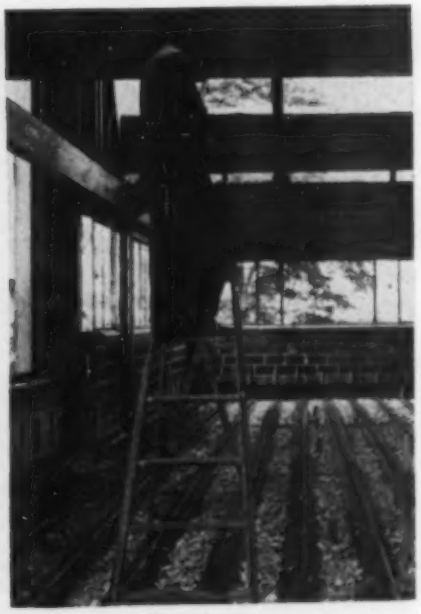
The manifold sections were moved as units to the site and integrated into complete grids on the site of the job



BOTTOM LEFT

The grids in place over the crushed stone base. The strips under the individual pipes are 1 in. insulating board. At this point the entire system was tested under 400 psi pressure for 2 hours; no leaks developed

In order to mark the location of the pipes so that the machinery could be anchored to the concrete without danger of damaging them, bench marks were placed on the joist directly above



construction in connection with ground moisture. Concrete is a relatively porous material which will absorb a considerable amount of water coming from either surface sources or rock formations. For this reason it is important that suitable precautions be taken to insure a dry floor. In any case, it is our recommendation that a 6 or 8 in. course of gravel or crushed stone be placed under the slab, with a waterproofing seal included between the two elements in locations where there is any reason to suspect the presence of appreciable water. Of course, good drainage practice such as would normally be followed under and around the foundation of any structure is definitely advised.

There have also been a great many installations made involving wood floor construction. Usual practice has been to lay the flooring directly over the coils, nailing the flooring either to sleepers or to joists notched to receive the pipes. The air space thus enclosed should be effectively blocked off so as to prevent the movement and consequent loss of heated air.

Sinuous Coil or Grid?

The actual pipe runs usually take the form of sinuous coils, or grids in which a supply manifold concurrently feeds a number of runs which feed into a return manifold. Both types have their individual merits. The sinuous coils are usually less expensive to fabricate and a little easier to design. However, the frictional head developed usually climbs so rapidly with increases in the total length that the range of practical working pressures limits this type of coil to either small structures or small areas of large structures. The grid type coil, although normally requiring a few more welds, embodies better hydraulic and thermal distribution characteristics. The vagaries of individual designs prevent making any broad statements as to the relative merits of the two coils, but it would be safe to say that the grid type coil is generally adaptable to large structures and the sinuous coil to small ones.

Insulating Against Downward Heat Flow

The question of insulation against downward heat flow from pipe coils placed on or near the ground is not as serious as many people believe. It is not quite possible to determine the exact amount of this loss, but some general calculations can be made. These indicate that approximately 30 per cent of the total heat input will be dissipated to the ground in uninsulated installations while a figure of 20 per cent is fairly accurate for cases in which insulation is used. This may seem a little high at first glance but the percentages are based on a total heat loss for the room or structure which does not include any heat losses downward. Consideration of this factor would greatly reduce the percentages just mentioned and provide a much more favorable comparison with downward losses from the conventionally heated structure. Furthermore, experience tends to indicate that these assumed rates of downward heat loss are very generous and that in actual practice they are much less than the figures I have given you. At any rate, we recommend continuing their use until additional research makes more accurate calculations possible. Considering this experience, the designer's question of whether to use insulation under the pipes becomes largely a matter of achieving results in keeping with the economic characteristics of the structure.

Venting and Draining the Pipe Coils

The matter of venting the pipe coils of a radiant heating system seems to be one of personal opinion. Actual installations are about divided between those which incorporate air vents from the pipes and those systems which are vented only at the expansion tank. A great many authorities insist that vents be provided; while just as many equally good authorities contend that a low velocity, low temperature, forced system does not require venting at any point except the expansion tank. So far, we have heard of only one installation made without vents which seemed to suffer to any degree as a result. This particular installation embodied coils on four different levels—a single closed system in which the highest coil was farthest from the boiler. Apparently an air lock developed because circulation in this highest coil was resumed as soon as a vent was tapped into the high spot.

Present practice seems about evenly divided between systems which can be completely gravity-drained and those which can be only partially drained or not at all. Where positive drainage was desired, a suitable tap has been included at the low point in the system and all lines pitched about ¼ in. in 10 ft. In slab-type structures, a small, drained pit is cast around the tap, when pouring the slab, and covered with a suitable traffic plate. However, where functional studies have indicated that drainage was seldom needed, practice has been to simply install a tap and count on using compressed air to blow the lines clear if it were ever desired to drain the system.

As to the selection of the circulator, this type of equipment is so well-known and highly developed that the only comment I feel constrained to make is that care should be taken to choose a pump of sufficient capacity rather than resort to the fairly common practice of shaving a few dollars by the use of an undersized pump. Certainly the installation of a pump of the right size would seem to be absolutely necessary in a well-engineered installation.

Does Floor Get Too Hot?

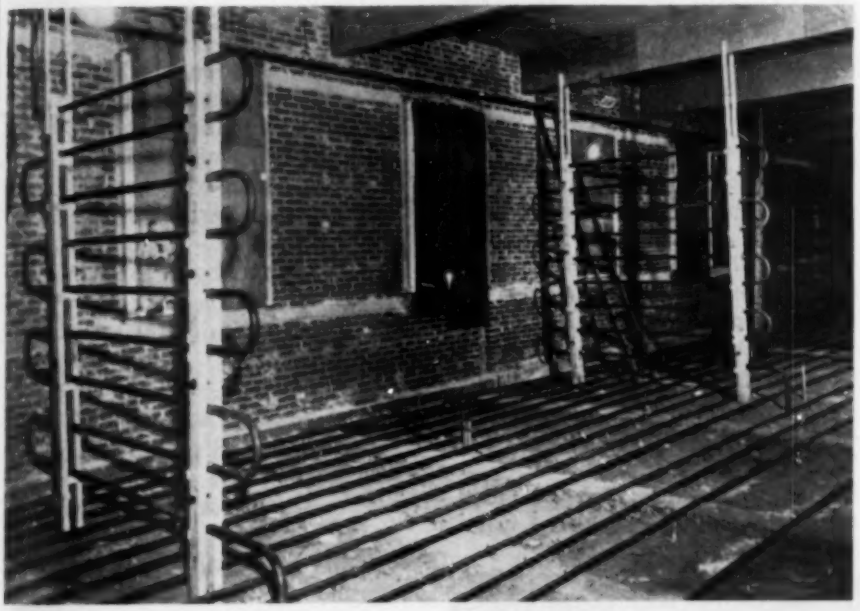
Among the questions most often asked about floor type systems are "Doesn't the floor get too hot?" and "Will it work with wood floors or rugs?" The answer to the first question is that a properly designed system will never produce floor surface temperatures above 85 F and this temperature—based on the experience of hundreds of installations—is not excessive. As a matter of fact, it is almost impossible to tell where the heat is coming from in a properly designed in-

stallation even though floor temperatures do reach 85 F. This surface temperature question also bears a relation to the question of floor construction and coverings. However, I believe it is safe to assume—again basing the assumption on the results of a great many installations involving all types of floor construction and coverings—that just about any of the common materials can be used.

The matter of insulation is one which should receive just as much attention in a building having a radiant system as is given to the same problem when a conventional heating system is used. There is no economic justification for heating large portions of the great outdoors. Thus, a few dollars' worth of insulating materials really constitutes an ounce of prevention and will usually result in a more contented user.

Temperature Control

A somewhat unlooked-for characteristic of radiant heated space is that air temperatures closely follow the mean radiant temperature. This means that the ordinary room thermostat will provide a thoroughly suitable means of control. In most systems, thermostats of this type are wired to the circulator and close observation adequately proves this control scheme to be satisfactory. As a matter of fact, control design in a radiant heating system is subject to exactly the same latitude that is available for the conventional forced hot water system. Such devices as boiler water aquastats, anticipating thermostats, mixing valves, etc., will add just as much to a radiant system as they will to any other but their use is no more necessary than is normally the case.



Heat losses were rather high in a few small closed-off outside rooms. To supplement output from the floor coils, wall coils were installed, as shown

A view down the long grids just before the concrete floor was poured for a large personnel building at another plant. Incidentally, this is one of the largest radiant heating installations in this country; approximately 20,000 ft of wrought iron pipe was used. After the floor was poured and dried a covering of asphalt tile was laid

POSTWAR AIR CONDITIONING ... a Billion Dollar Industry?

Walter L. Fleisher—president of Air & Refrigeration Corp., consulting engineer, and member of HPAC's board of consulting and contributing editors—predicted in 1925 that air conditioning would be a billion dollar a year industry. He still thinks so—and he gives here some of his reasons. Postwar air conditioning applications are broken down into eight classifications, with comment on the future possibilities of each and notes on their importance

IN 1925, talking before a group of heating contractors, I predicted that air conditioning would become a billion dollar a year industry in a few years. Billions weren't talked about as casually in those years as they are now, and the talk made the front pages of the newspapers simply because of the billion dollar prediction.

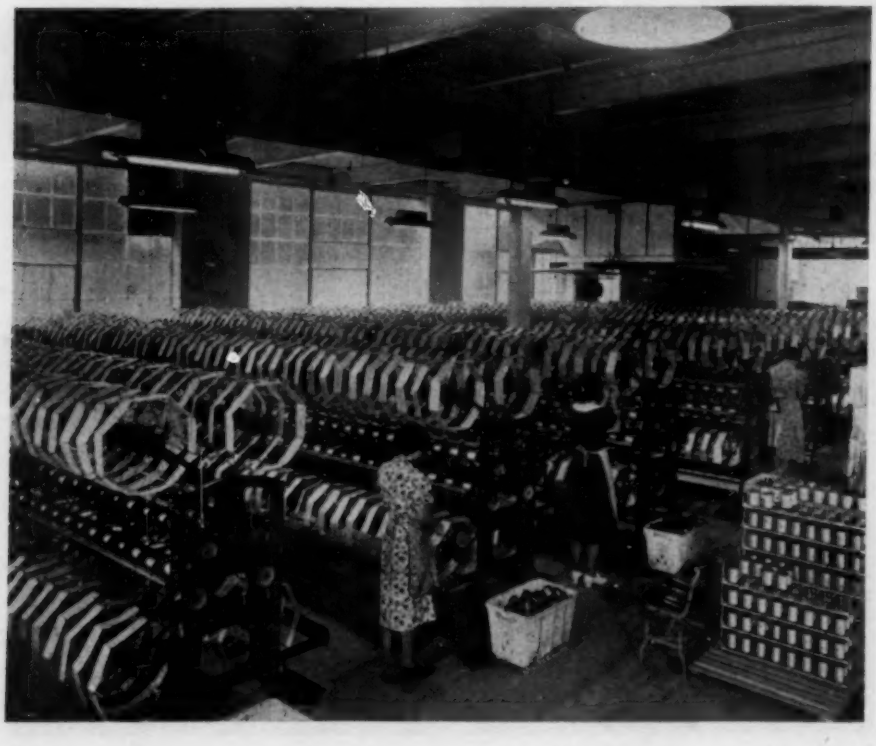
In the 19 years since then, air conditioning never approached this figure, what with the depression and the war and many other factors that retarded its growth. In a way I believe that the refrigeration manufacturers and the medical profession were as much to blame as anyone or anything for its retardation.

Though most people don't realize it, proper winter heating is as much an air conditioning problem as summer cooling, and the rationing of fuel in the last two years has made us aware of the comforts of heat—or, at least, the discomforts of cold—as no lecturing or advertising could ever have done.

Let us see then what we in the profession can do to build this industry of air conditioning to the billion dollar level. In the first place let us be sure that we know what we're talking about when we go to sell air conditioning to the public. Every system that controls or has the ability to control temperature, humidity, and air movement at the same time is air conditioning. The refrigeration manufacturers insisted that for air conditioning one must have a refrigeration machine, and the doctors and physicists weren't at all sure of the necessity of humidification. Between them they destroyed the faith of many people toward doing anything. The war hasn't helped much either, because when we were making quite an approach to all year 'round air conditioning in our war factories, the WPB decided that air conditioning for comfort was not essential and cut it out of practically all new construction, unless it could be shown to be essential to the proper production of goods.

Great Promise for the Future

But certain things have happened in the last two years that give great promise for the future of air conditioning. The first is that enough factories were equipped to give labor a taste of its pleasures and its benefits. Those plants are going to get the cream of labor when production at competitive costs is going to be the difference between profits and bankruptcy. One building of a group air conditioned is going to be the lever by which labor will demand it in others of the same group. Then the saving in construction and the maintenance costs with and without air conditioning is going to be another factor in the demand for air conditioning from both the labor and economic angles. I know from personal contact that a number of the very largest industrial plants are contemplating new construction after the war and are giving very serious consideration to complete air conditioning, where in their present plants they have nothing but ventilation. In the analysis of the advantages of complete air conditioning, the elimination of monitors or skylights with the necessary increased heights and the maintenance of windows



At a rayon textile mill in the south, the reeling and bobbin rooms are completely air conditioned with unitary systems, controlled temperature, humidity, and air cleaning being combined in ceiling suspension apparatus of the capillary type to maintain a relative humidity of 60 per cent

and their cleaning have been very carefully balanced against the cost of complete air conditioning. It is surprising, or at least it was surprising to the industrialists with whom I cooperated, that there was so little increase in cost, all of these other things being taken into consideration, of complete air conditioning over old type buildings and adequate ventilation.

But industry alone is not going to make a billion dollar business of air conditioning. So what are the potentials on which the air conditioning industry can be built?

Divide Potentialities into Eight Classes

We can divide these potentialities into eight classes, with a reason for the development of each class. As I have already mentioned industry, let us tackle this problem first.

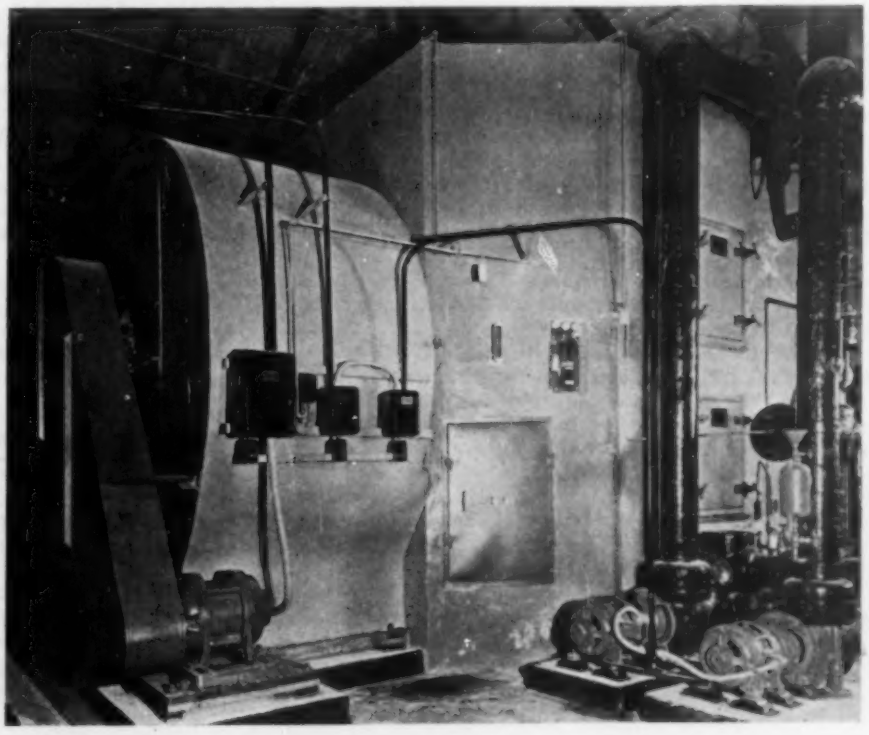
1) In industry—The one accredited condition that makes for the use of air conditioning is the requirement of set conditions for the processing of goods. This applies to the textile industries throughout—cotton, silk, rayon and wool; to the manufacture of precision instruments and machinery having close tolerances; to the processing of foods and the manufacture and use of the new synthetic rubbers; to the removal of toxic volatiles which are so prevalent in the new processes and new materials of manufacture brought about by the necessities of substitute materials due to the war.

2) In industry—For the comfort and health of the worker. It has already been demonstrated that hot industries, deep mines, and foggy interiors can be definitely improved from the angle of both comfort and health by adequate air conditioning. Investigation along this line has been carried on for many years, but the number of places of this type unconditioned is still so great that one can consider the field as practically untouched.

3) In places of assembly—Air conditioning here may be considered a luxury, but it can soon become an economic necessity when unconditioned places of assembly have to compete with conditioned places. This is an enormous and almost untouched field. This division applies to the theaters which are unconditioned. According to statistics, of the one group of buildings which we always think of as being air conditioned—that is, theaters—there are only 17 per cent properly conditioned, and this is the field in which major air conditioning for comfort started. Department stores, hotels, office buildings, ships, trains, buses, and apartment houses are practically untouched, and as most of these depend on transient trade, which is extremely fickle, a start in this field would lead to an impetus which could not be stopped. In a review of this field for the Real Estate Board of Greater New York, in 1938, I figured that at $1.00 to $1.50 a square foot of rentable space there was at least $100,000,000 of air conditioning required for half the buildings in this city alone.

4) In hospitals and convalescent homes—There is no question as to the necessity—and I underline "necessity"—for air conditioning in hospitals. All of the operating wards are cognizant of this fact but have been handicapped by lack of money and uncertainty on the part of the engineering profession as to what is required. It has been demonstrated that convalescence proceeds much more rapidly with nearly ideal conditions than without, and there is a certain feeling that the control of disease can be more easily handled under proper atmospheric conditions than with the variations in conditions due to changing and fluctuating weather.

5) For the householder—Air conditioning in the home may also be considered a luxury, but as many people think we are going to build our postwar economic scheme on the providing of luxuries for the home this should soon be taken out of the luxury class and be considered a necessity, just as much as modern plumbing. When all of the types of structures that I have mentioned in class 3 have been equipped, the public will have learned the advantages and the desirability of air conditioning and will demand it as their inalienable right. The movie theaters are an example of what happens when a few reap the profits because of their willingness to gamble on results. It is my feeling that the prosperity of the movie industry would not have been achieved without air conditioning, which made it possible to operate throughout the year and provided places of assembly in the hot weather for those seeking relief; and to earn a profit over a 12 month period, where, before air conditioning, at least five months of darkened houses turned



Well water is the source of cooling for a pharmaceutical house

the balance of the year into a deficit.

6) In industry—Again I return to industry to bring out another point. The simplest way to have air conditioning desired in industry is to show an economic return. If it can be shown that production increases only a few per cent due to the installation of air conditioning, the appeal to the industrialist will be on a basis which he understands better than anything else. As an example, in a discussion with one of the largest industrialists regarding this particular phase of the air conditioning in industry situation, we figured that the entire cost of complete air conditioning was only 2 per cent of the yearly payroll, and that if production could be increased by only 2 per cent the air conditioning would be paid for in a single year. It is obvious that this microscopic increase in production is a foregone conclusion and is one of the best arguments to present to industry in advocating the installation of air conditioning.

7) In the school and home, for comfort.

8) In the school and home, for health.

These latter two headings cover, in my mind, one of the greatest potential fields for air conditioning of any of the headings I have enumerated. The trend toward positive air circulation in the home has grown steadily for the last few years, but only lately has it been shown that the vaporization of glycol in a *properly humidified atmosphere* will instantaneously sterilize the air to kill cold and 'flu and some types of pneumonia virus, preventing the spread of these diseases. Some type of air conditioning is required to bring this condition about. Its potentialities are unbelievably great. When all America goes in for life insurance you can be sure that when, for little money and a better heating system, one can obtain a certain assurance of avoiding these diseases, one will hardly be able to keep people from improving their heating systems with a simple type of air conditioning, which can be extended to year-'round air conditioning as one's finances permit.

What the Engineer Must Do

This whole picture is drawn as a project and a possibility, but the engineer has a tremendous job to do before it can be accomplished. He must overcome prejudice and intolerance—and by intolerance I mean intolerance of what the other fellow thinks is adequate. He must promote cooperation so that the proper air conditioning is designed and specified and promoted. He must simplify and improve his design so that he can maintain a cost which is commensurate with the ability of the consumer to pay. He must take into consideration all of the idiosyncrasies of the user.

Finally, he must get the public to demand what he has to sell rather than force the public to accept something for which they have no inclination. If all of these things are done, if all of the phases and classes that I have indicated are carefully followed up and pursued, I really believe that the billion dollar industry to which we have all been looking forward for many years may readily become a possibility in the postwar reconstruction.

Recent Amendments to OPA Fuel Oil Rationing Order

An index to amendments Nos. 1 *to* 50 *to the fuel oil rationing order appeared on pp.* 171-172 *of the April* 1943 *HPAC. Amendments* 51-60 *were covered on p.* 233, *May; amendments* 61-65 *on p.* 52, *front section, June; amendments* 66-71 *on pp.* 411-412, *August; amendments* 72-73 *on p.* 466, *September; amendments* 74-78 *on p.* 537, *October; amendments* 79-82 *on pp.* 174-175, *back section, November; and amendments* 83-88 *on p.* 661, *December.*

Amendment 7 *to supplement* 1, effective November 30, 1943, sets the value of one unit represented by coupons numbered "2" on class 4 coupon sheets; the value of five units represented by coupons numbered "2" on class 5 coupon sheets; and the value of 25 units represented by coupons numbered "2" on class 6 coupon sheets, at ten (10) gallons, fifty (50) gallons, and two hundred and fifty (250) gallons of fuel oil, respectively.

In the midwest (the section of the fuel oil rationed area lying within PAW district 2) which includes zones A-2, B-2, and C-2, and in the southeastern states which comprise zone D-1, the same unit value has been established for period 3. In these areas the coupon validity for periods 2 and 3 has been combined.

Amendment 89, effective December 1, 1943, invalidates as of this date the definite value change-maker coupons on class 1 and 2 sheets. These change-maker coupons expired for consumers as of September 30, 1943.

Amendment 90, effective November 30, 1943, establishes the procedure for handling late applicants for fuel oil rations for heat and hot water. It provides that a late applicant is a person who applies after November 30, 1943, for a ration for 1943-44 heating year for heat and/or hot water. The amendment authorizes the boards to deduct from rations for such late applicants such amounts as are no longer needed because of the expiration of a substantial part of the heating year.

Amendment 91, effective December 24, provides that fuel oil rations may be issued for use in coal spraying equipment if the oil is one of the heavy industrial types. Coal transported in open freight cars must be sprayed with heavy oil to prevent it from being blown off. It has been estimated that some 5,000,000 tons of coal will be saved annually by eliminating this windage loss. This amendment follows the Petroleum Administration for War's recent action easing its restriction on the transfer and acceptance of heavy grades of oil for spraying coal. Grades 5 and 6 and bunker C oils, used primarily by industrial and other large consumers, may be employed for the purpose.

Amendment 92, effective January 6, establishes the procedure for issuance of additional rations, application for which is made to local boards on OPA form R-1104 (revised). Additional rations when current ration is insufficient for specified purposes, to avoid undue and immediate hardship, and to replace unavoidable loss of fuel oil are all included.

Engineers Volunteer for Fuel Efficiency Campaign

Nearly 4000 engineers have volunteered for service in behalf of the Bureau of Mines fuel efficiency program "and new enlistments are pouring in daily," Secretary of the Interior Harold L. Ickes announced December 10.

Designed to minimize wasteful practices in the use of coal, coke, wood, petroleum, and gas as a part of the government's critical resources conservation campaign, the program is being organized by a recently appointed National Fuel Efficiency Council, with the cooperation of the Bureau of Mines.

A HISTORY OF PIPING

M. A. Hasselmann (of Tube Turns, Inc.) has set himself the job of writing a history of "man's greatest transportation system" — piping. In this — the sixth of a group of articles published in Heating, Piping & Air Conditioning — he traces the development of wrought iron pipe and methods of manufacturing it. Piping's past history is as interesting as are its many and varied uses

THE SMALL quantity of wrought iron pipe that was manufactured before 1825 was made largely by the hand or blacksmith shop methods used to make rifle barrels during the preceding 500 years. Making cast iron, lead, or brass pipe was easier and less expensive; they could be made in longer sections, and fewer (not more) of the troublesome connections were desirable. However, after 1825 wrought iron pipe came into wide usage.

Wrought iron is composed of iron and iron silicate, a glass-like slag. It is the original form in which iron was used—the ductile, forged iron of Vulcan, Woden, and Thor. It is worked—wrought—by hammers or rollers, from a pastey, molten mass. This working places the silicate in thread-like filaments within the matrice of pure iron, giving a characteristic fibrous structure. Silaceous slag was originally present because it could not be kept out and was long regarded as undesirable. However, the corrosion and fatigue resistance claimed for wrought iron, especially valuable in piping, and other characteristics are due to these barriers of rust-resisting slag.

When gun powder and guns came along, wrought iron was the only ferrous metal available for making gun barrels. Cast iron was still to be developed, although it came soon after. Steel, difficult to make, was available only in small strips and was used for knives, swords, daggers, files, cutting tools, etc. Crucible steel was not developed until 1740 by Huntzman, an English clockmaker, and Bessemer steel, the first steel suitable for piping, was not available until 1855. Wrought iron was used for suits of armor, shields, etc., the old armorers knew how to work it, and naturally turned to it for the first gun barrels.

To make a barrel for a gun light enough for a man to carry, the early gunsmiths heated wrought iron and pounded it out into a thin sheet. This sheet was cut into long narrow strips, called skelp. Then this skelp was heated and, a few inches at a time, pounded by hand around a rod into a tube. The skelp was wide enough so that the edges overlapped, and this overlap was pounded into a weld. At first this overlap was an actual overlap, later the two edges were beveled or scarfed and the weld seams did not appear as a raised ridge.

To save the gunsmith's arm in pounding out skelp, and to facilitate various kinds of forging work, the trip hammer was invented during the mid-1600's. The trip hammer was a large, weighted hammer, mounted on a fulcrum and raised by water power to a given height, where it tripped and fell to an anvil or mandrel. The heated metal was held against the anvil or mandrel. The British countryside is spotted with old "hammer ponds."

Rolling Mills

There is no evidence of a rolling mill strong enough or highly powered enough to roll wrought iron plate until the latter part of the 1700's. Leonardo da Vinci, in the 1400's, designed mills for rolling zinc sheets to be made into pipes for pipe organs. During the 1600's glass makers had small mills for rolling lead strips for leaded window panes. By 1725 plumbers could buy "milled lead" sheets for making eavestroughs and downpipes. Mills for rolling iron originated in Alsace in the early 1700's. In 1750 a Welshman applied to the King of England for patent protection on the use of such mills. The process became known as the Welsh method and was followed until the present methods for continuous hot rolling of sheet and strip were developed in the 1920's.

It was almost 1800 before iron rolling mills could roll sheet large enough and thin enough to make rifle barrel and pipe skelp. At that time wrought iron boiler plate was available in England in untrimmed sheets no larger than 15 in. wide by 3 ft long.

First Machinery for Making Wrought Iron Pipe

Naturally, hand formed tubes, whether intended for gun barrels or for pipe, were rough and irregular. And while gun barrels justified further refinement—small-hammer tapping on the outside and boring on the inside—pipe did not justify such costly finishing. However, straight pipe of uniform diameter and smooth interior was desirable and in 1808 Benjamin Cook, an Englishman, patented the first wrought iron pipe mill. It consisted of four grooved rollers centered in the same pipe-crossing plane and pressing the pipe on top, bottom, and sides. This mill straightened heated, hand formed pipe and, by reducing its cross section slightly (and extending its length) gave it a uniform outside diameter.

By 1812, while rolled sheet was available for making needed sizes of wrought iron pipe, the pipe was still entirely hand formed—pounded by hand into a tube shape and, with a hand hammer, lap welded. That year Henry Osborne put a set of dies on a trip hammer that facilitated the curving of the skelp and the pounding of the lap weld over an inserted mandrel. Osborne's patent was an improvement, although it still left the manufacture of wrought pipe a slow, tedious, and expensive process.

In 1825, James Russell who, with his brother, John, had been gun barrel and gas tube manufacturers in England since 1811, filed an important patent. It was in two parts and the first part provided for butt welding small sizes of wrought iron

pipe by pounding the two unscarfed edges of skelp together. This was accomplished by split dies, one on top and one on the bottom of the trip hammer. The skelp had to be bent by hand or trip hammer in a preceding operation. No mandrel was inserted; instead, Russell relied on the collapse-resisting strength of the circle. Russell reasoned that the butt welded seam was sufficiently strong for piping, and that only gun barrels justified lap welding.

While the first half of Russell's patent was exceeded one month later by Whitehouse's welding bell patent, the second half was a development that is indispensable to much piping today — the screwed coupling. His patent provided for threading the ends of pipe and screwing these into a threaded short section of larger pipe.

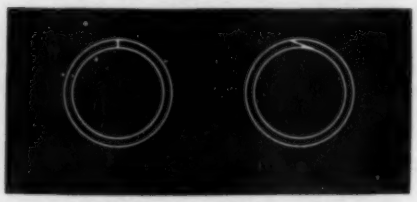
Whitehouse's Welding Bell

Cornelius Whitehouse, like Russell, worked for years to achieve a simple, mechanical weld for pipe and his thinking went several steps further. Whitehouse first provided a simple mechanical means for bending the flat skelp into a tube. This was a bell-shaped die which, as the red hot skelp was drawn through it, curled the edges up and around until they almost met. Then this bent skelp, reheated, was drawn through a second and slightly smaller bell-shaped die, which pressed the edges together firmly and completed the forming of the pipe.

Drawing through the dies was done on a bench which mounted a hand operated windlass that attached to a hooked rod ("tag") welded to the skelp. The dies were split and mounted on tongs to facilitate a quick change from the bending to the welding die, handling the hot skelp, and starting the bending and welding. They rested against an upright on the draw bench. By heating and drawing half of the skelp at a time, first one end and then the other, pipe twice as long as the furnace and the draw bench could be made.

Throughout the 1800's this process was improved upon, although it is basically the same method by which butt welded wrought iron and steel pipes are made to this day. First the windlass was replaced by an endless chain with a geared drive. Then the draw bench got a "buggy" which hooked into the draw chain and provided means for attaching the tag to it. It supported the skelp (or the pipe) at a fixed height. Eventually the draw chain was power driven.

By 1875 some plants had skelp furnaces and draw benches long enough to enable them to heat the full length of the skelp and to draw it full-length. However, at least one company persisted in the old "draw-a-half-at-a-time" method until well into the present century.



Butt weld, left, and lap weld, right

In 1875, George Matheson combined the skelp bending bell and the skelp welding bell into one funnel-shaped bell and mounted it in a fixed position on the draw bench. In 1895 tongs were patented that hooked in the draw chain and, reaching through the welding bell, hooked into the skelp and eliminated the tags. In 1897, Peter Paterson patented a furnace in which the unheated skelp was inserted at one end and the heated skelp drawn out at the other end. Four years later the first Paterson-type furnace for making 40 ft butt welded pipe was put in operation. Speed, straightening, and finishing refinements have followed since.

Machine-made Lap Welded Pipe

When butt welded pipe was developed, it was such a sensation and so satisfactory that everyone forgot, temporarily, lap welded pipe. But not for long. In the swiftly developing Machine Age, butt welded pipe was soon unequal to certain services. The weld was not strong enough and, besides, there was need for wrought pipe larger than the largest obtainable by the butt weld process. Alert pipe manufacturers like James Russell saw that machine-made wrought iron pipe with a stronger seam and in larger sizes just had to come.

Russell set himself to the task and about 1835 was manufacturing lap welded pipe from scarfed skelp by the following machine methods: (1) The skelp was bent into tubular form by a die such as used in the first operation of making butt welded pipe. In bent lap weld skelp, however, the scarfed edges finished one above the other. (2) The bent skelp was reheated and a chain, attached to an iron ball, or mandrel, the diameter of the inside of the finished pipe, was dropped through it and secured to the mill. (3) The pipe was rolled between two grooved rollers, one above the other and the top one centering on the unjoined edges of the skelp. The mandrel was held in position between the rolls by the chain and the pressure of the rollers against the pipe and mandrel formed the weld.

As he had done with Whitehouse on butt weld pipe, Russell was racing, unknowingly, with another inventor of a machine for making lap weld pipe. This other inventor, Martin Jones, had invented an identical mechanism but with four welding rolls instead of two. Jones, after exhausting his own and his wife's funds, appealed to a friend to help him market his invention. The friend applied for the patent in his own name and licensed it to a firm in England. About the year 1840, a bitter contest developed in the courts, resulting in a victory for the Russells.

Refinements have been added to Russell's and Jones' original lap weld machines through the years, especially during the present century. Making the mandrel bullet-shaped and mounting it on a rod which held it rigidly in position between the rolls occurred early. Machines for rolling the scarfed edges into the skelp, replacing the original slitting method, appeared in the 1880's.

With the development of the welding bell and, a decade later, the lap welding machine, the manufacture and use of wrought iron pipe increased by leaps and bounds the world over.

Lap welding wrought iron pipe by the hammer weld method is used today to form large sizes, 16 to 30 in., and occasionally larger. Hammers are power driven, of course, and the edges of the skelp are continuously heated by flames.

Electric and oxyacetylene welding are also used for these large diameters.

Other Developments

While methods of forming and welding were of primary importance in making wrought iron pipe available in quantity and at low prices, the improvements in methods of making wrought iron were notable contributions in this direction at various times. In 1784 Henry Cort developed the "dry puddling" process by which refining could be speeded up. Cort hollowed out (dish-shaped) the bottom of the reverberatory furnace first used for wrought iron about 1766. In this furnace only hot gases, no fuel, contacted the metal. In 1811 Aubertot made use of the carbonic gases, theretofore allowed to burn uselessly at the top of the furnace. In 1828 Neilson invented the hot blast. In 1830 Hall put an oxide bottom in Cort's sand bottomed puddling furnace, cutting down iron loss. Mechanically operated furnaces have been developed through the years: Dank's, 1868; Roe's, 1905; Ford's, 1920; and Ely's, 1921. The Aston process, developed in 1930, is not a furnace but a mechanized method for carrying out the production of wrought iron in separate pieces of equipment, each specially designed for its purpose. Aston developed the process in which all impurities are removed from the molten iron in a Bessemer converter and the right amounts of silaceous slag and other elements put back in.

Galvanizing was applied to wrought iron pipe early. This process of applying corrosion resisting zinc to ferrous objects originated in Europe in the 1600's. Sometimes the early pipe makers coated the pipe with tin or lead.

Wrought Iron Pipe Joints

No bell and spigot wrought iron pipe was ever made in the United States. The small quantities used here have been imported. The smaller sizes of wrought iron pipe have always been threaded. As threads and thread dressings were improved, this type of connection became very satisfactory. After 1850 wrought pipe was obtainable with a coupling welded on—the open end of the coupling and the opposite end of the pipe threaded.

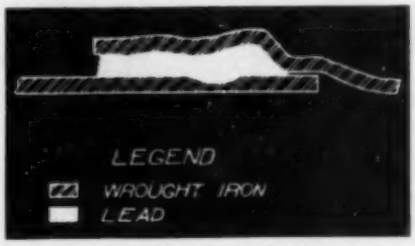
Some of the medium sizes of wrought iron pipe—those used as oil well casing, for example—have always had threaded connections. The rest of these middle sizes had flanged couplings. The flanges were first attached to the pipe by pressure welding, or shrunk on and peened. Later flanges were threaded and screwed on. Attaching flanges by gas or electric welding is a comparatively recent development.

As operating pressures, especially steam and oil refinery pressures, were increased, flanges attached by pressure welds or threads became inadequate. They became loose or warped. About 1896, the Van Stone joint, also known as the lap joint, was conceived. It provided for sliding the flange, unthreaded, over the pipe and then flaring or welding a narrow ridge or semi-flange on the end of the pipe. This flared end was machined and faced the flared and machined end of the adjoining section of pipe, separated, of course, by a gasket. The bolted flanges, wide enough to give clearance to large nuts and holding against the narrow semi-flanged ends of the pipe, could be drawn together with greater tension. The Van Stone joint was the forerunner of several other pipe connections, including the flared end coupling for brass and copper tubing and the pipe union.

Other bolted pipe connections have been developed since the Van Stone that hold to plain ends of piping. While these have had considerable application, their use since welding has been curtailed.

Large sizes of wrought iron pipe, such as used for water mains, at first had riveted seams and some riveted connections between sections. The usual joint was bolted flanges that were riveted to the pipe or shrunk to it. Such pipe can now be joined by welding.

A bell and spigot joint for wrought iron pipe. This is a cross section from an 8 in. gas pipe recently removed in almost a perfect state of preservation, after giving 51 years of service. The pipe was imported from Scotland as ballast. There was no packing in the joints—just poured lead. (Courtesy Louisville Gas and Electric Co.)



Pipe Threading

There is evidence that within the ten years between 1800 and 1810 the idea was conceived for joining pipe with threaded connections. However, as already explained, the idea did not take hold until 1825 when Russell patented his threaded coupling. At that time the idea of threads for bolts and nuts was about 600 years old. Bolts and nuts were first used on suits of armor during the 1200's, for just the final closures, after the wearer got inside. The rest of the armor's plates were held with rivets or rawhide, each rawhide connection carefully protected. The threads of these bolts were hand filed and the threads of the nuts were forced by the bolts. The first thread cutting lathe was set up in 1564; the first geared lathes appeared about 1740. By the time of our Revolutionary War most American iron working shops had a set of homemade "blacksmith's taper taps and jamb plate." The jamb plate was flat and long with handles extending from each end. It contained dies for each of the taper taps, each die forced from its respective hand filed taper tap. However, jamb plates and taper taps were rarely applied to pipe and pipe fittings. Pipe threading was done on lathes, using chasers. For years the chaser was held by the operator against the slide rest and moved along by him—no wonder there were so many difficult-to-turn pipe connections and no standardization!

The first pipe threading machines were developed by C. C. Walworth. A mechanical genius on production machinery, he invented a machine for drilling and tapping tees in one operation in 1855, and a machine for threading pipe in 1859. During most of the 1800's pipe manufacturers made their own taps, dies, and threading equipment.

The first to standardize pipe threads was Whitworth, who introduced his tables in England in 1841. Included were tables headed "Whitworth standard tube threads for gas and water pipes." They were

Fuel Conservation Reminders

(From Scotty-Grams, a bulletin issued to operating personnel of the Chicago Board of Education by John Howatt, chief engineer, and member of HPAC's board of consulting and contributing editors)

High water in the boiler retards rate of steaming, reduces steam space and may cause water to be carried over into the piping system.

Oil or foreign matter in the boiler water causes slow steaming and unsteady water level. It will make heat transfer more difficult and cause heat waste up the stack.

Steam from the vapor pipe shows a leaky valve somewhere. Check for it and make the correction.

Overflowing the receiving tank or frequent popping off of boiler are unnecessary wastes of fuel.

Dirty air filters retard flow of air. Keep them clean so air circulation through the building will be properly maintained. Recirculated air should be cleaned.

Defective air valves waste fuel. If they do not permit air to escape radiators become air bound and ineffective. If they permit steam to escape they act as fuel leaks.

Encourage students to develop the "shut the door habit" and not to loiter in the doorways. With double doors at vestibules the outside door should be closed when the inside door is opened.

Patch all broken window glass as soon as discovered. Do not try to heat all outdoors.

Greater comfort is experienced when a plus air pressure is maintained on the building. This checks drafts and stops complaints. At least one-third outside air to the ventilating system will be necessary to accomplish this.

Shut all air supply and heat off of vacant rooms. Do not temporize on this order. Here is one place much fuel can be saved without discomfort.

not tapered. In 1862 Robert Briggs, of Philadelphia, compiled formulas and tables for tapered pipe threads which, 24 years later and after his death, became the American Standard Briggs pipe thread. It is doubtful whether Briggs conceived the tapered thread, as there are fittings equipped with tapered threads that antedate his tables. It is probable that he recognized the superiority of tapered pipe threads and set about standardizing them and making them popular.

Fittings for Wrought Iron Pipe

Before the invention of machine-made wrought iron pipe in 1825, all fittings for wrought iron piping were cast. Between that date and 1850 making fittings of wrought iron became common practice in England and men became highly skilled and proficient at the work. Since that time wrought pipe systems have been assembled with cast iron, cast brass, cast bronze, and forged iron fittings. Cast and forged steel fittings have been developed since the turn of the present century; malleable fittings somewhat earlier. Use of welding fittings is a growing practice.

Until the opening of the Croton aqueduct in New York City in 1842, which was a great stimulus to the production of valves and fittings in the United States, most of these items were imported. At that time a number of American manufacturers began making turns, tees, crosses, laterals, etc., many calling their products "Croton type." English craftsmen were frequently imported for this work. A visitor to an early (1852) fittings plant remarked years later: "In a miserable, dark basement were six Englishmen making fittings . . . There were the little circular forges . . . There was the skelp iron . . . They would take it and cut it and shape it on their anvils, and they were turning out fittings pretty lively . . . all ready for tapping."

Valves

In America and abroad, valves were first made by the builders of the steam engines, gas light equipment, water systems, and heating systems requiring them—later they were made by specialized manufacturers. Flanged connections for valves have always been used. From the time threaded connections became common, valves had both male and female threading. The male threading was far less common, being required only when the small sizes of threaded belled cast iron pipe were used. Collartype nuts, holding the flared end of pipe against a male-threaded valve or mechanism, were inspired by the Van Stone joint and appeared after 1900. A big difficulty with valves was their lack of standardized connections, not accomplished until the 1920's.

[Of some assistance in the writing of this article was the cooperation given by the A. M. Byers Co.]

WPB Announces Material Allotment for Manufacture of Heating Controls

The War Production Board announced December 4 that a special allotment of controlled materials has been provided for the manufacture of certain heating system controls at the request of the Office of Civilian Requirements for the purpose of conserving fuels.

Materials were provided for the manufacture of the following equipment:

Domestic temperature controls:

200,000 barometric dampers for space heaters.

400,000 barometric dampers for central heating plants.

Commercial temperature controls:

5000 control sets composed of outside-inside thermostats, motors, linkages, valves, relays, transformers.

15,000 control sets composed of thermostats (inside), motors, linkages, valves, relays, transformers.

15,000 barometric dampers.

The WPB's plumbing and heating division will allocate the supplemental, controlled materials to all manufacturers who are able to produce the specified types of heating system controls. In allocation, prime considerations are:

1) Manufacturers in labor areas Nos. 3 and 4 will be favored in allotting material over manufacturers in labor areas Nos. 1 and 2.

2) Manufacturers requesting controlled materials to produce equipment for the fuel conservation drive must show that such production will not affect their active production and shipment of direct war contract equipment.

3) Material will not be allocated to a manufacturer who cannot show that he can reasonably expect to produce the total quantity of equipment he requests material for, in time for distribution and installation during the 1943-1944 heating season.

Manufacturers desiring to produce any specified number of the above types of equipment should file a separate CMP-4B application under code No. 594, heating system controls, and mark the application "Fuel Conservation Drive Controlled Materials" in the upper border.

Manufacturers are free to distribute and sell the above listed heating system controls without a priority rating if they are built of fuel conservation drive controlled materials, since they are listed on schedule A of order L-79.

Heating, Piping & Air Conditioning

AMERICAN SOCIETY of HEATING and VENTILATING ENGINEERS

Journal Section

Control of Air-Streams in Large Spaces

By G. L. Tuve* and G. B. Priester**, Cleveland, Ohio

This paper is the result of research sponsored by the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS and conducted at Case School of Applied Science

SUMMARY—Results of tests with about 45 sizes and kinds of non-directional discharge outlets have been correlated with data from other investigations and an equation is proposed for the relationship between the velocity at the outlet face, the outlet size and the highest residual velocity at any cross-section of the stream in the room. This maximum residual velocity at a given section was found to be about three times the average velocity at that cross-section. Beyond 25 diameters from the outlet face, and until the maximum velocity falls to less than 500 fpm, the maximum residual velocity in the stream was found to be inversely proportional to the distance from the outlet. Beyond the section where the maximum stream velocity was below 500 fpm, the velocity reduction took place more rapidly.

A jet issuing from a rectangular slot becomes almost circular in shape and follows approximately the same laws as apply to the stream from a round or a square outlet of the same area, although for very narrow slots the entrainment ratio was found to be greater and the throw slightly less. The maximum residual velocity for air streams from very narrow slots (¼ in. to ½ in.) varied inversely as the square root of the distance from the outlet for distances less than 20 diameters. Dividing the outlet area into multiple nozzles or into two or more separate slots made little difference, unless these separate outlets were spaced several inches apart. The effective angle of all straight-flow jets over the major portion of their travel in a room was found to be very close to 20 deg.

Introduction and Object

WHEN ONE or more streams of air are projected into a room or space, for ventilation, heating, cooling or any other purpose, the designer of the system needs basic information on the behavior and control of these streams. A program for the securing of this basic information is being directed by the ASHVE Technical Advisory Committee on Air Distribution and Air Friction. This paper is the second report dealing with the characteristics of a primary air-stream in an unconfined space, *i.e.*, a space large enough so that the primary stream is not disturbed by contact with surfaces, or by adjacent streams.[1] The designer has a wide choice of air distribution patterns by varying the size, shape and type of approach to the air discharge outlet, and by controlling the velocity and temperature of the air supply. Present knowledge dealing with the performance of such air-streams is scattered and incomplete. This paper presents experimental evidence in support of certain methods for calculating this air-stream performance.

Scope and Methods

Considering the behavior of a free air stream as a jet pump, it was demonstrated in a previous paper[2] that the theory of conservation of momentum could be satisfactorily applied. Experimental results were presented, showing that for every foot of travel of the primary stream away from the outlet, a fixed percentage of room air is entrained, and this percentage was found to be independent of the outlet velocity. These results were based on about 20 common sizes and shapes of outlets, with face velocities of 400 to 2400 fpm, and at distances from the outlet up to about 30 diameters.

Additional studies have now been made with outlet velocities up to 7000 fpm, aspect ratios from

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For presentation at the Annual Meeting of the American Society of Heating and Ventilating Engineers, New York, N. Y., January 1944.

[1] ASHVE Research Report No. 1204—Entrainment and Jet-Pump Action of Air Streams, by G. L. Tuve, G. B. Priester and D. K. Wright, Jr. (ASHVE Transactions, Vol. 48, 1942.)

[2] Loc. Cit. Note 1.

Table 1—List of Tests for Maximum Residual Velocity in Air Streams
(High Velocity Series)

Test No.	No. of Readings	Size of Outlet Inches	Type of Outlet	Area Sq Ft	Range of Outlet Velocities Min. fpm	Max. fpm
4 & 5	113	10 x 10	Square Nozzle	0.694	1092	6750
7	112	8½ x 8½	Square Nozzle	0.50	1295	6430
9	82	6 x 6	Square Nozzle	0.25	1390	6740
11	90	4¼ x 4¼	Square Nozzle	0.125	1408	6720
12	72	3 x 3	Square Nozzle	0.062	2150	7010
15	62	2⅛ x 2⅛	Square Nozzle	0.031	2820	6700
6	87	25 x 4	Slot Nozzle	0.694	1264	6760
8	87	24 x 3	Slot Nozzle	0.50	1580	6900
10	90	24 x 1½	Slot Nozzle	0.251	1395	6900
13	100	24 x ¾	Slot Nozzle	0.125	1275	6850
14	81	24 x ⅜	Slot Nozzle	0.062	2400	6930
16	52	24 x 3/16	Slot Nozzle	0.031	1600	6850
17	80	11⅞	Round Nozzle	0.769	1405	6600
18	88	8¼	Round Nozzle	0.371	1318	7060
19	90	6	Round Nozzle	0.196	1283	6910
20	84	11⅞	Round Orifice	0.769	1282	6760
22	88	8⅝	Round Orifice	0.417	1580	7080
21	57	2½	Round Orifice	0.034	1515	7030
22	43	16 x ⅜	Slot Nozzle	0.042	2190	7000
23	52	Two 8 x ⅜	Slot Nozzle	0.042	1510	7040
24	62	Three 5.3 x ⅜	Slot Nozzle	0.042	1725	6990
25	52	Four 4 x ⅜	Slot Nozzle	0.042	1820	6920
26	51	Five 3.2 x ⅜	Slot Nozzle	0.042	1940	6460

1 to 128, outlet areas from 4 sq in. to 100 sq in. and both rounded-entrance and square-edged approach to the outlet. Long slots have been studied, as well as rectangular, square and round outlets. Readings of air-stream velocity have been taken from 3 ft to 90 ft distant from the discharge face.

One of the disadvantages of the momentum theory and similar methods for calculating air stream performance is that these calculations deal with *average* velocities, whereas in practice the *maximum* velocity within the stream is likely to be more important. A study has therefore been made to determine what maximum velocity is continuously maintained within any cross section of the stream. For given outlet conditions it is desired to know at what cross section of the stream in the room the velocity does not exceed say 100 fpm, or 500 fpm. The range from 100 fpm to 1000 fpm was extensively studied for all shapes, sizes and outlet velocities included in Table 1.

Some results have been obtained with single long slots, two slots in parallel (one above the other), and multiple slots side by side; also with grilles of the square-perforated and steel bar types. Work is in progress on long, continuous slots as used in ceiling outlets, and on plates having small perforations. Additional work will be done on heated and cooled air streams projected horizontally or at a slight angle, and on heated and cooled streams diffused by wide-angle grilles.

The entire approach to the problem has been primarily experimental, in an effort to correlate with the theoretical analyses already available in the literature (see section on *Analysis and Correlation*), and to determine the empirical constants or factors necessary for application of theoretical equations.

Experimental Procedure

The chief requirements for satisfactory experimental measurements are a well controlled stream from the discharge outlet, a large free open space in front of the outlet, and suitable methods for measuring air velocities. Most of these tests were made in a large laboratory room about 75 ft wide and 125 ft long with a 40 ft ceiling. The air discharge unit shown in Fig. 1, was located at one end of this laboratory. A similar setup in a smaller room was used for some of the low velocity tests, and for those tests in which the entire cross section of the stream was traversed with a velocity meter as described in the previous paper, see Fig. 3.

Each test was conducted by two observers and each observer independently took readings of the room air velocity with a separate instrument. The general procedure was to establish the required outlet velocity and then make a complete series of observations in the discharge stream, with periodic check of velocity at the outlet face. In the tests to determine maximum velocities at various distances from the outlet, the measurements were made at room air velocities of 1000, 500, 400, 250 and 100 fpm. A typical data sheet for one of these tests is shown in Fig. 3.

Preliminary studies were made with various instruments for measuring the room air velocity[3], but the velometer was found to be the most convenient instrument and hence it was used for most of the tests. Similar tests were also made with an anemometer of the rotating vane-wheel type, but this instrument was not sufficiently sensitive at the lower velocities, although a large number of tests at higher velocities gave good agreement between the velometer and the anemometer. The air-stream velocity by velometer was in all cases the estimated average velometer reading over a period of about one

[3]ASHVE Research Report No. 1140—The Use of Air Velocity Meters, by G. L. Tuve, D. K. Wright, Jr. and L. J. Seigel. (ASHVE Transactions, Vol. 46, 1940.)

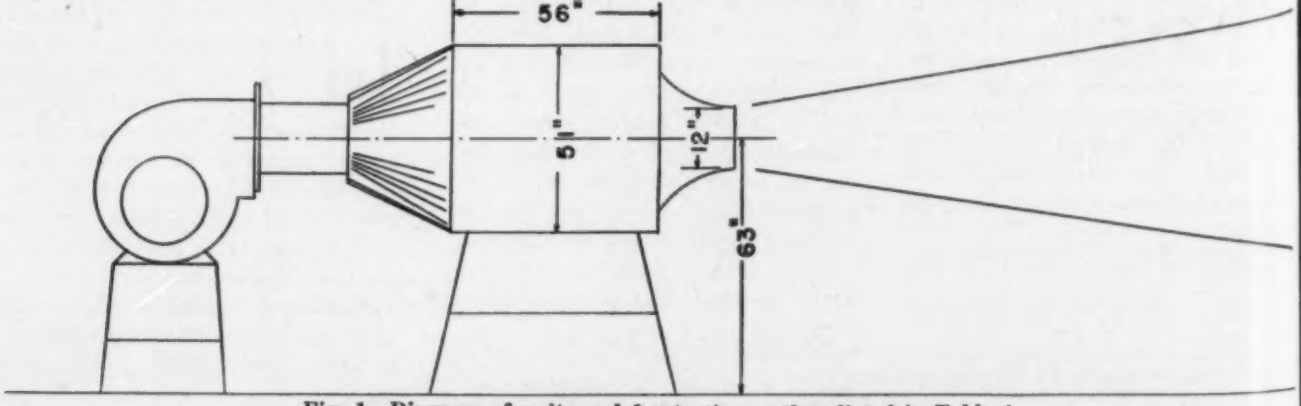

Fig. 1—Diagram of unit used for testing outlets listed in Table 1.

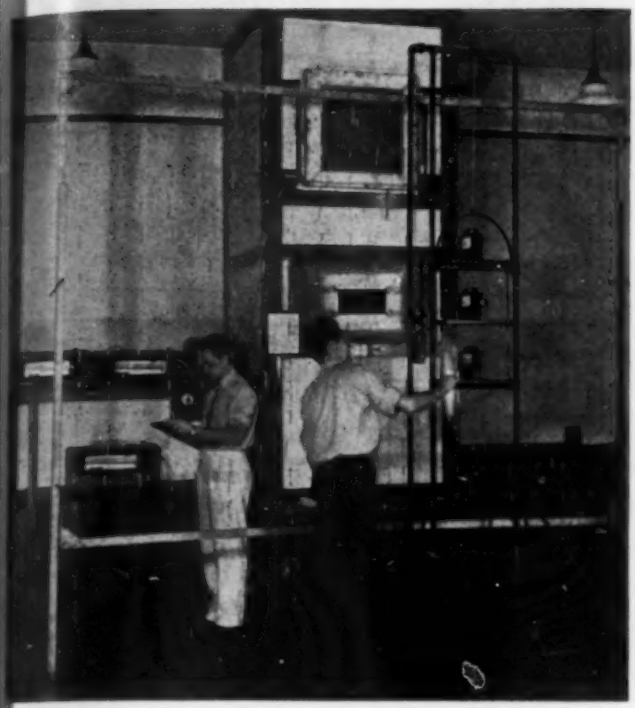

Fig. 2—Observers conducting stream-traverse test.

A.S.H.V.E. RESEARCH - AIR-OUTLET THROW DATA

Test No. 18 Outlet Size 8.25" Nozzle Outlet Area 53.46

Barometer 29.48 Duct Temperature 89° Date 6-26-43

Observers KEW - SMF

Pressures		Face Velocity Fpm.	Velometer No. 14 Actual Reading 132 264 335 454 1040					Velometer No. 11-12 Actual Reading 149 274 470 574 1100				
Impact	Static	4070√h"	Corrected for Calibration 100	250	400	500	1000	Corrected for Calibration 100	250	400	500	1000
.105	.105	1318	31	15	11			30	15.5	10		
.155	.156	1602	36	24	15	11		39	21	14	11	
.20	.20	1820	48	25	17.5	14.5		45	25	17	14	
.27	.27	2115	50	30	21.5	17.5		48	31	21	16	
.365	.360	2445	58	32	23	18		56	36	23	18.5	
.51	.51	2910	73	42	29	26	10.5	73	40	28	22	11
.685	.685	3340	80	44	35	29	11.5	77	46	33	27	13
.91	.91	3880		54	41	34	15		55	41	34	16
1.46	1.46	4920		77	59	45	18		77	60	43	21
2.05	2.06	5830			75	56	24			73	56	26
2.42	2.42	6335			83	61	27			80	61	27
2.99	3.01	7060				72	32					

Fig. 3—Typical data sheet used for tests listed in Table 1

minute, corrected for velometer calibration.

It will be recognized from Fig. 1 that beyond a distance of about 30 ft from the outlet face, there was some interference due to the primary stream striking the floor. This produced higher velocities at or near the floor, but this disturbance did not seem to extend into the stream above the 18 in. level. When measuring the maximum velocities, occurring 5 or 6 ft above the floor, the maximum-velocity curve for a small outlet with a total throw of about 25 ft was identical with the pattern obtained with a large outlet having a total throw of 100 ft. Hence it was decided that the floor interference was not serious as long as the velocities were measured only at the higher level.

In order to determine the relations between maximum velocity and average velocity at any cross section of the stream, a series of tests were made in the smaller room in which readings were taken at the center of each 6 in. square across the entire air stream, including all velocities above 10 fpm. A large grid of 6 in. squares was formed by threads stretched across a frame, and results were recorded on a data sheet that was ruled as a small scale reproduction of this traverse grid as shown in Fig. 4.

When rounded entrance nozzle outlets were being tested, the outlet velocity was determined by means of an impact tube connected to a sensitive inclined manometer. For all other types of outlets the face velocity was obtained by accurately metering the primary air quantity, and dividing this metered air quantity in cfm by the area of the outlet in square feet. By measuring the static pressure on the inlet side, the *coefficient of discharge* of the various outlets and the true outlet velocity could be computed.

The rounded-entrance outlets of

24"-1" FREE OPENING VEL. = CFM/AREA = 1200

TEST NO. 26 DATE 8-16-41 DISTANCE - 9 FT.

OBSERVERS: GBP & HWE

			0	0	0	0	0	0				
		0	30	40	20	10	0	50	0			
		0	60	90	100	90	50	40	0			
		0	100	150	170	160	70	100	30	0		
	0	10	110	150	210	180	100	110	50	0		
	0	20	130	180	250	250	150	90	50	0		
0	10	10	140	170	270	250	170	80	40	0		
	0	0	170	170	300	290	180	50	20	0		
	0	20	140	140	250	240	160	70	10	0		
	0	50	90	120	170	210	120	50	40	0		
		0	40	70	120	120	120	0	0			
			0	20	50	80	60	0				
				0	0	0	0					

Fig. 4—Typical data sheet for stream-traverse test

square and rectangular shape were made from heavy wood blocks, and the orifices and round nozzles were of the standard metering types. The grilles were commercial units mounted in the usual frames. A group of the outlets tested are shown in the photograph, Fig. 5.

Experimental Results

Maximum Velocity At Any Cross Section

Actual experimental points were plotted on two sets of curves for all the tests listed in Table 1. In both cases the throw or distance from the outlet face was used as the abscissa. In one set of curves, Fig. 6, the residual centerline velocities in the room air stream are plotted on the ordinates, and each curve represents a given outlet velocity. The maximum velocity in the stream decreases as the distance from the outlet face increases. In the other set of curves, Figs. 7 and 8, the various outlet velocities appear on the ordinates, with a curve for each room velocity.

It was recognized that in order to correlate the test results obtained with various sizes and shapes of outlets and types of approach, dimensionless values should be plotted. Hence the ordinates were changed to represent residual velocity in the room in per cent of the outlet velocity, and the throw

or X-distance was measured in *outlet diameters*. Samples of these curves of V_r/V_o versus $X/\sqrt{A}$ are shown in Fig. 9. Composite dimensionless curves, on logarithmic coordinates are presented in Fig. 10.

From the results of this series of tests, as shown by the graphs similar to Figs. 6, 7, 8 and 9 (which were plotted for all tests listed in Table 1), it is concluded

Table 2—Values of K for Equation 1

Maximum Residual Velocity	Maximum Outlet Velocities; FPM				
	1000	2000	3000	4000	5000
500 fpm or above	...	...	6.0	6.2	6.4	6.8
400 fpm	...	...	5.6	5.9	6.2	6.5
300 fpm	...	5.0	5.2	5.4	5.7	6.0
200 fpm	...	4.6	4.8	5.0	5.2	5.4
100 fpm	...	3.7	3.7	3.8	3.9	4.0

that the maximum air velocity at any cross section of the stream beyond 25 outlet diameters downstream varies *approximately* as follows:

1. Residual velocity is directly proportional to outlet velocity.

2. Residual velocity is directly proportional to the *effective diameter* of the outlet.

3. Residual velocity is inversely proportional to the distance from the outlet.

If these three statements were exact, the relation could be stated in a very simple equation. Since an examination of Figs. 6 to 10 will show that *these statements are only approximate*, there are two alternatives, (1) Use a more exact equation, and (2) Use the simple equation with a table showing variations in the constant of proportionality. Since the second method is usually preferred by mechanical engineers, it has been adopted here.

Equation for Performance of a Straight-Flow Outlet:

$$V_r = \frac{C\,V_o\,D_o}{X} = \frac{K\,V_o\sqrt{A_o}}{X} \quad (1a)$$

$$= K\,\frac{Q}{X\sqrt{A_o}} \quad \ldots\ldots\ldots (1b)$$

where:

Q = volume of air discharged from outlet, cubic feet per minute.

V_r = residual maximum velocity in air stream, *i. e.*, the highest maintained velocity at the given cross section in the room.

Table 3—Coefficients of Discharge and Velocity Ratios
(Free Openings Plenum Approach)

Size in Inches	No. of Tests	Velocity = CFM/Area	Distance in Feet	Avg. Ratio of Max. Vel. to Avg. Vel.	Coefficient of Discharge
24 x 3	7	400-1200	9	2.6	0.84
18 x 4	3	400-1200	9	2.8	0.78
14.4 x 5	3	400-1200	9	2.4	0.74
12 x 6	6	400-2400	6 & 9	2.7	0.81
10.3 x 7	3	400-1200	9	2.8	0.71
8.5 x 8.5	3	400-1200	9	2.7	0.81
24 x 2	3	600-1200	9	3.2	0.81
24 x 1	8	800-2400	6 & 9	2.8	0.66
24 x 0.5	9	800-2400	6 & 9	2.6	0.67
4.9 x 4.9	8	800-2400	6 & 9	2.9	0.81

V_o = average velocity across the effective area of the outlet.
= average velocity across measured gross area divided by (coefficient of discharge) × (free area).

A_o = effective area of outlet, see Table 5.
= (gross measured area) × (free area, decimal) × (coefficient of discharge).

X = normal distance from outlet face.

C and K = constants of proportionality. (Values of K are given in Table 2.)

Ratio of Maximum Velocity to Average Velocity

All results given in Figs. 6 to 10 and summarized by Equation (1) apply to the maximum velocity at cross section in the room, parallel to the outlet face. In order to determine air entrainment or quantity of air in motion, the *average* velocity must be obtained. Partial results of about 150 traverses by the grid method (Fig. 4), are given in Table 3.

Discharge Coefficients

Coefficients of discharge were computed for rectangular orifices with plenum approach. From the results of about 50 tests, shown in Table 3, it appears that this coefficient increases as the aspect ratio increases. Often it is not feasible to use an orifice in practical installations. Therefore in Table 3 are given the values of coefficients of discharge for actual grilles and registers tested. It is noted that this value is approximately 0.8.

Shape of Stream

Air streams from the narrow rectangular outlets listed in Table 4 did not retain this shape for more than a few diameters from the outlet. In each case the rectangular air stream became approximately circular. The curves of velocity reduction (Fig. 6), for the rounded entrance slots were almost identical with the curves of the square nozzles of the same outlet area (see Table 1 for sizes).

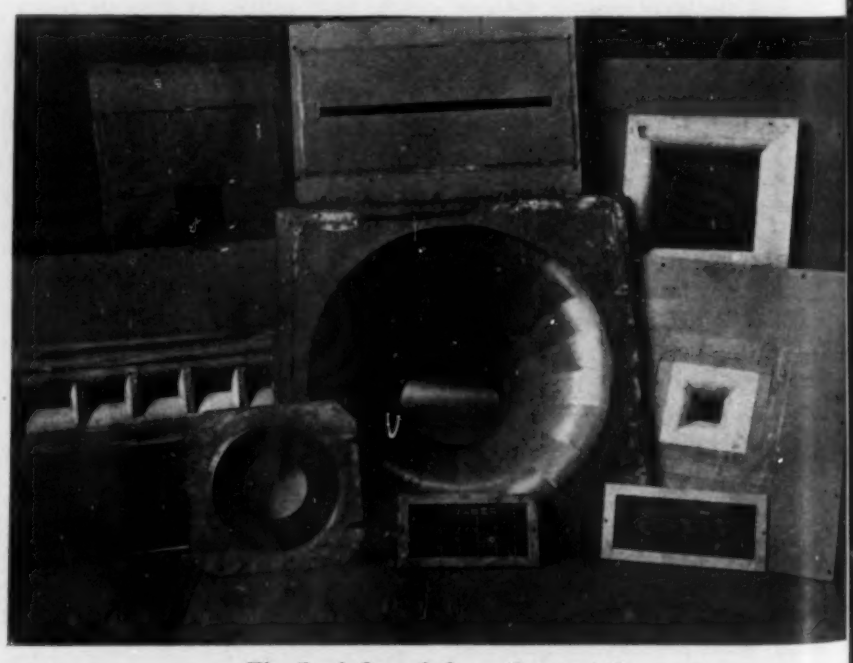

Fig. 5—A few of the outlets tested

The average jet angle for slot orifices as determined by measurements taken at 6 and 9 ft from the outlet, are compared to the average angle calculated from the entrainment ratio values. Equation (2) based on the momentum theory was used to solve for the angle.

$$\text{Entrainment ratio} = \frac{Q_x - Q_o}{Q_o} = \sqrt{\frac{A_x - A_o}{A_o}} = \sqrt{\frac{A_x}{A_o}} - 1 = \left[\frac{\pi(r_o + X \tan \Theta/2)^2}{a_o b_o}\right]^{1/2} - 1 \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

where $r_o = \left(\frac{a_o b_o}{\pi}\right)^{1/2}$

and b_o = outlet dimensions
X = distance from outlet
Θ = average jet angle

The angles calculated from the entrainment ratios are almost the same as the observed angles, as shown in Table 6.

Maximum Residual Velocity for Slots

Fig. 11 appears to confirm the theory that for a short distance from the outlet the maximum residual velocity for slot outlets varies inversely as the square root of the distance from the outlet. Beyond this region there is a transition period followed by the region where the maximum residual velocity varies inversely as the first power of distance from the outlet.

Experiments indicate that there is a region close to the discharge face for all outlets whether slots, square or round openings in which the maximum residual velocity varies inversely as a fractional power of the distance from the outlet (see Figs. 6 and 11). This relation gradually changes as the distance increases until the velocity varies inversely as the first power of the distance.

Table 4—Outlets Tested by Grid Traverse Method

Size in Inches	Type	Approach
12 x 6	Free Opening	Duct
12 x 6	Free Opening	Plenum
12 x 6	Bar Grille	Duct
12 x 6	Nozzle Grille	Duct
12 x 6	Square Punch	Duct
20 x 8	Free Opening	Duct
20 x 8	Bar Grille	Duct
21 x 6	Bar Grille	Duct
14 x 4	Free Opening	Duct
12 x 12	Free Opening	Duct
8.5 x 8.5	Free Opening	Plenum
20.29 x 7	Free Opening	Plenum
14.4 x 5	Free Opening	Plenum
18 x 4	Free Opening	Plenum
24 x 3	Free Opening	Plenum
24 x 2	Free Opening	Plenum
24 x 1	Free Opening	Plenum
4.9 x 4.9	Free Opening	Plenum
24 x ½	Free Opening	Plenum
24 x ¾	Free Opening	Plenum
24 x ¼	Double Slots	Plenum

Analysis and Correlation

Decrease of Velocity Along Axis

The theory of the spreading and mixing of turbulent jets has been presented by Tollmein (1926), Batemen (1931), Goldstein (1938),[4] and others. Two extreme cases are usually treated, (1) jets from symmetrical outlets, and (2) jets from infinite slots. The theory indicates that the maximum velocity along

[4] Modern Developments in Fluid Dynamics, British Aeronautical Research Committee, edited by Goldstein, (*Oxford University Press* p. 592),

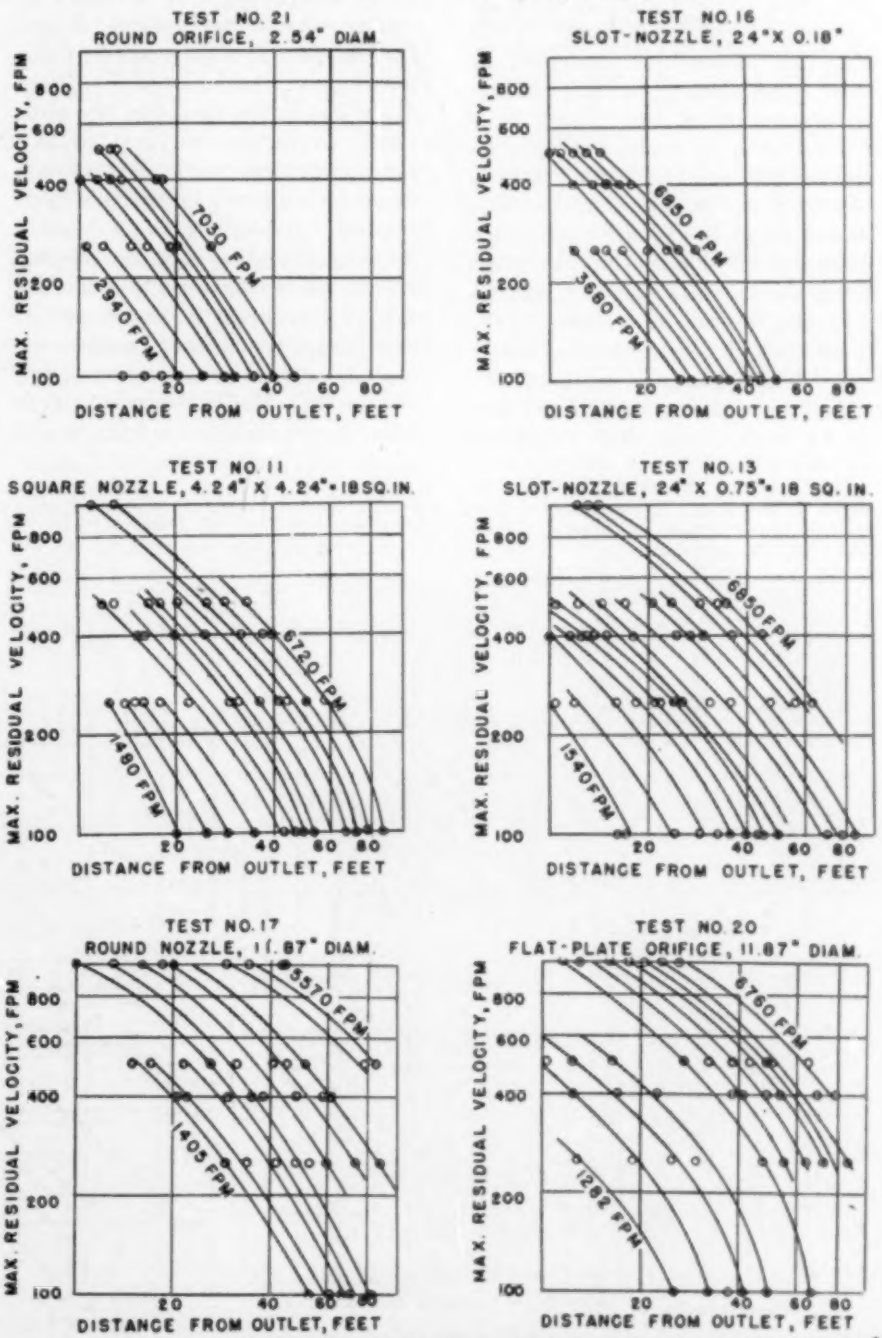

Fig 6—Typical logarithmic graphs of room velocity vs. distance, one curve for each outlet velocity

the axis of a symmetrical jet should vary inversely as the distance from the outlet, but that if the stream issues from an infinitely-long slot, the maximum velocity varies inversely as the *square root* of the distance from the outlet. In other words, the velocity-reduction in the case of a stream from a long slot, is less rapid than in the case of a round or square outlet. While this difference was indicated in the experimental results of the present study, the slots used in the tests did not approach an *infinite* length.

Another complication in the behavior of free jets has been well presented by McElroy, in a recent Bureau of Mines Report.[5] Four zones or phases are described by this investigator as the stream progresses from the outlet face: First phase, in which the axis velocity remains almost constant, second phase in which the velocity decreases as the square root of the distance; third phase in which the expansion is free and the velocity decreases as the first power of the distance, and fourth phase in which the velocity decreases more rapidly than before because of return flow or convection currents. From the tests made on the outlets listed herewith, Tables 1 and 4, all of these phases have been definitely recognized. Equation 1 is proposed as applying chiefly to the third phase or zone, extending beyond 25 diameters, but changing gradually after the centerline velocity has dropped below 500 fpm (see Fig. 10). An equation identical with Equation (1) is used by McElroy, and he proposes *a tentative value of* $K = 6$ *for average centerline velocities.* This is in reasonable agreement with the values recommended in Table 2. Similar values were obtained by Ruden[6], using a 2.8 in. round nozzle, as is shown by the agreement of curves *A*, *B* and *D*, Fig. 10. Probably some of the reduction of the value of K (Table 2), is due to the fact that the accidental convection currents in any space interfere with the stream when very low velocities have been reached. Ashley[7] has emphasized the fact that the residual velocity always decreases rapidly near the end of the throw in any practical case, because of the backflow or counter-current set up by the room circulation. McElroy reported that when a stream from a 5 in. round pipe had travelled 25 ft in a square mine drift 8 ft high, the maximum velocity was reduced, due to backflow, to 6 per cent of the initial velocity (Fig. 10, Curve *C*). This corresponds to a value of $K = 4.$ (when $V_0 = 7520$ and $V_r = 450$). It is concluded that the use of Equation (1) and the values of K in Table 2 are in reasonable agreement with the few data available from other sources.

Ratio of Maximum Velocity to Average Velocity At Any Cross Section

Complete traverses of the cross sections of a stream at great distances from the outlet become almost impossible because of the number of readings required. While over 200 such traverses have already been made in the course of this investigation, few of these were at distances exceeding 2[illegible] diameters, because, even at this distance a single traverse requires at least two hours. The results of about 150 tests indicated that the ratio of maximum centerline velocity to average velocity, was around 3 irrespective of outlet size or shape, or of initial air velocity.

In discussing the previous research paper in this series, Coogan and Goff[8] made graphical analyses

[5]Air Flow at Discharge of Fan Pipe Lines in Mines, by G. E. McElroy, (Bureau of Mines, Report of Investigations—No. 3730, November 1943).

[6]Ruden, P., Turbulente Ausbreitungsvorgange im Freistrahl: Naturwissenschaften, Vol. 21, 1933, pages 375-378.

[7]ASHVE Transactions 1942, p. 261.

[8]ASHVE Transactions, 1942, p. 262.

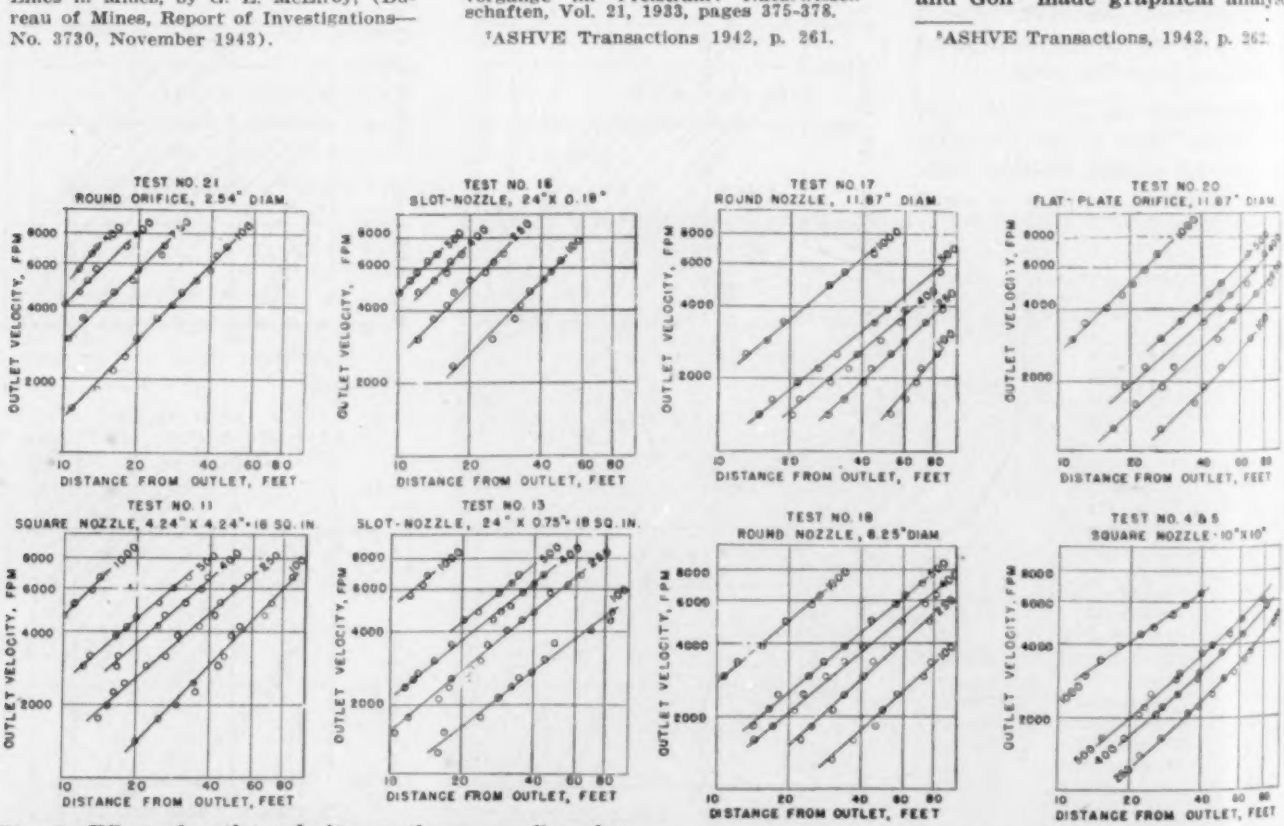

Fig. 7—Effect of outlet velocity on throw—small outlets. Numbers on curves indicate maximum residual velocity

Fig. 8—Effect of outlet velocity on throw—large outlets

Table 5—Discharge Coefficients for Registers and Grilles
(Plenum Approach CFM/Gross Area = 700/(1 × 0.5) = 1400 fpm)

Description of Outlets	Per Cent Free Area	Coefficient of Discharge
Grille ⅝ in. square openings; ¼" cross bars	45	0.870
Grille 13/16 in. square openings; 3/16" cross bars	51	0.788
Register 13/16 in. square openings; 3/16" cross bars	51	0.788
Register 81 vertical openings; Approx. 0.3" x 1.5"	53	0.799
Register vertical openings; 21/32", 4 15/16"; 12 vertical bars	58	0.770
Register rectangular openings; 11/32", 1⅜"; 10 horizontal, 6 vertical bars	59	0.821
Register rectangular openings; 3/16", 1 11/16"; 21 horizontal, 6 vertical bars	61	0.795
Grille rectangular openings; 3/16", 15/16"; 27 horizontal, 12 vertical bars	62	0.760
Register rectangular openings; 3/16", 15/16"; 27 horizontal, 12 vertical bars	63	0.748
Grille rectangular openings; 13/16", 1 11/16"; 5 horizontal, 6 vertical bars	66	0.758
Grille vertical openings; 13/16", 4¾"; 12 vertical bars	69	0.725

of the two traverses given by the sample data sheets in this previous paper, using the method described by Förthmann.[9] The authors have since plotted many traverses in this manner. McElroy made a similar analysis of his experimental data based on anemometer measurements, and also quoted a value of this ratio, $R = 2.6$, from Tollmein's experimental work on a round jet and $R = 2.4$ from Förthmann's experiments. The ASHVE GUIDE[10] states that the maximum velocity is *usually from 2.5 to 3.5 times the average.* However, a careful analysis shows that the value obtained for the ratio of maximum to average velocity depends to some extent on the instrument used for measuring the velocities. A lower minimum velocity can be measured by velometer than by anemometer. The value of $R = 3$ given above was determined from tests using the velometer. The anemometer is satisfactory for measuring centerline velocities, but since it is not usually accurate below 100 to 150 fpm, the total cross section traversed with an anemometer is actually smaller than with a velometer, because the latter may be read to 20 fpm or less. Hence the values of the velocity ratio reported as 3 to 1 by velometer, may be 2.5 to 1 when the same stream is traversed with an anemometer. For practical purposes in evaluating air quantities, mixing and air movement, a ratio of center velocity equal to 3 times the average should be fairly accurate, for distances from 10 to 50 diameters from the outlet. It is probably close to the same for greater distances.

[9] See *N.A.C.A.* Tech. Memo. 789, 1936.

[10] HEATING, VENTILATING, AIR CONDITIONING GUIDE, 1943, Chapter 31, Air Distribution, p. 592.

Table 6—Calculations Versus Tests
(Free Open Slots Plenum Approach cfm/area = 800 ft/min)

Outlet Size in Inches	Average Measured Jet Angle	Entrainment Ratio at 9 Feet	Calc. Angle Using Actual Entrainment
24 x 3	22.5°	4.62	23.2°
24 x 2	23.0°	6.37	24.0°
24 x 1	23.5°	8.47	24.6°
24 x ½	22.5°	11.85	24.2°
24 x ¼	22.5°	17.75	25.4°

Jet Angle and Air Entrainment

The quantity of room air entrained may be computed from the jet velocities if the total area of the jet can be determined. If a conical jet discharges from a round outlet, and the angle of the jet is known, the area at any section is of course easily determined, and by multiplying this by the average velocity across the section, the volume-rate of flow is obtained. It

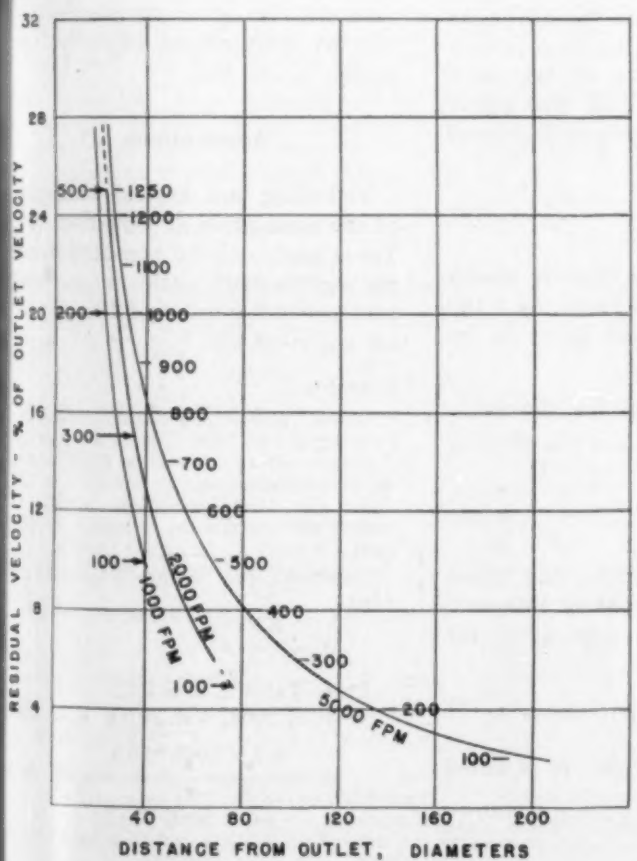

Fig. 9—Dimensionless plot of residual velocity vs. distance from outlet; rectangular coordinates.

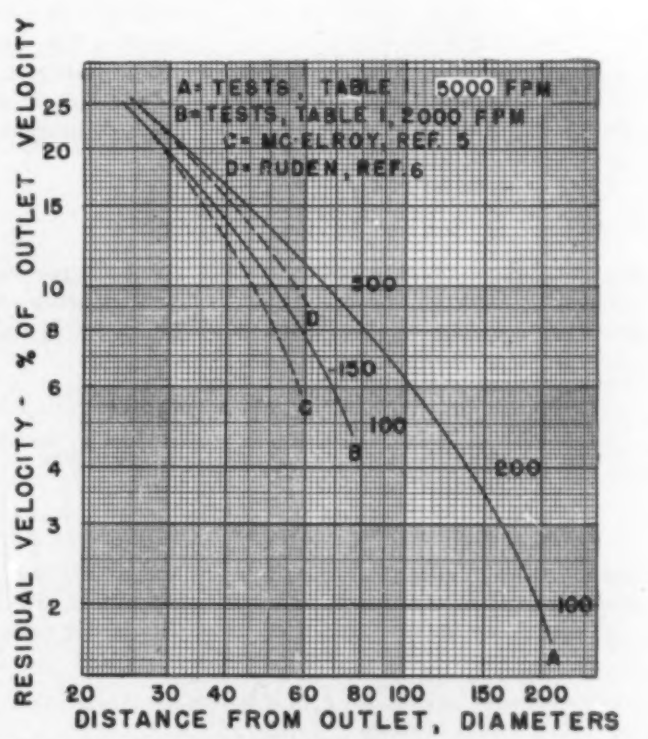

Fig. 10—Dimensionless plot comparing results of three investigations

has been incorrectly assumed by certain investigators that the jet retained the shape (aspect ratio) of the outlet. Actually, the stream becomes almost symmetrical within a few diameters from the outlet face if the aspect ratio of the outlet is less than 100; hence, for calculating the performance of the stream beyond 10 diameters, it is incorrect to base the calculation on the shape of the outlet. Accepting this fact that there is a short transition length within which the stream is converted to an approximately symmetrical shape, the stream beyond this section may be considered conical, and the entrainment may then be calculated if the jet angle is known, and the apex of the cone is located. Since round and rectangular jets of the same area were found in this investigation to be practically the same beyond 20 diameters from the outlet, it appears logical to assume the apex of the cone is in the same location for any jet, as long as the aspect ratio of the outlet is small. The volume flowing at any section then becomes:

$$Q_x = A_x V_x \quad \ldots\ldots\ldots\ldots\ldots (3)$$

But assuming a round jet and using Equation (1):

$$V_x = \frac{V_r}{R} = \frac{K V_o \sqrt{A_o}}{R X},$$

$$A_x = 0.785 \left(D_o + 2 X \tan \frac{\theta}{2} \right)^2,$$

$$Q_x = \frac{0.785 K V_o \sqrt{A_o}}{R X} \left(D_o + 2 X \tan \frac{\theta}{2} \right)^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

On the basis of *effective outlet area* as used in Equation 1: $Q_o = A_o V_o$. Then the equation for entrainment ratio may be written as follows:

$$\frac{Q_x - Q_o}{Q_o} = \frac{Q_x}{Q_o} - 1$$

$$= \frac{0.785 K}{R X \sqrt{A_o}} \sqrt{\frac{A_o}{0.785}} + 2 X \tan \frac{\theta}{2} \Bigg)^2 - 1 \quad \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Assuming a 20 deg jet angle, this becomes:

Entrainment Ratio =

$$\frac{0.785 K}{R X \sqrt{A_o}} \left(\sqrt{\frac{A_o}{0.785}} + 0.35 X \right)^2 - 1 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

Two factors that affect entrainment ratio are variation in outlet area and extreme variation in aspect ratio. Fig. 12 shows the comparison of a slot (aspect ratio 24 to 1), and a square opening of the same area. The entrainment ratio is about 18 per cent greater for the 24 to 1 slot. By doubling the aspect ratio of a slot and at the same time dividing the area by two, which means using a slot of the same length but of one-half the width, the entrainment ratio is increased about 50 per cent. This is shown by comparing slots 24 in. by 1 in., 24 in. by ½ in., and 24 by ¼ in. (Fig. 12).

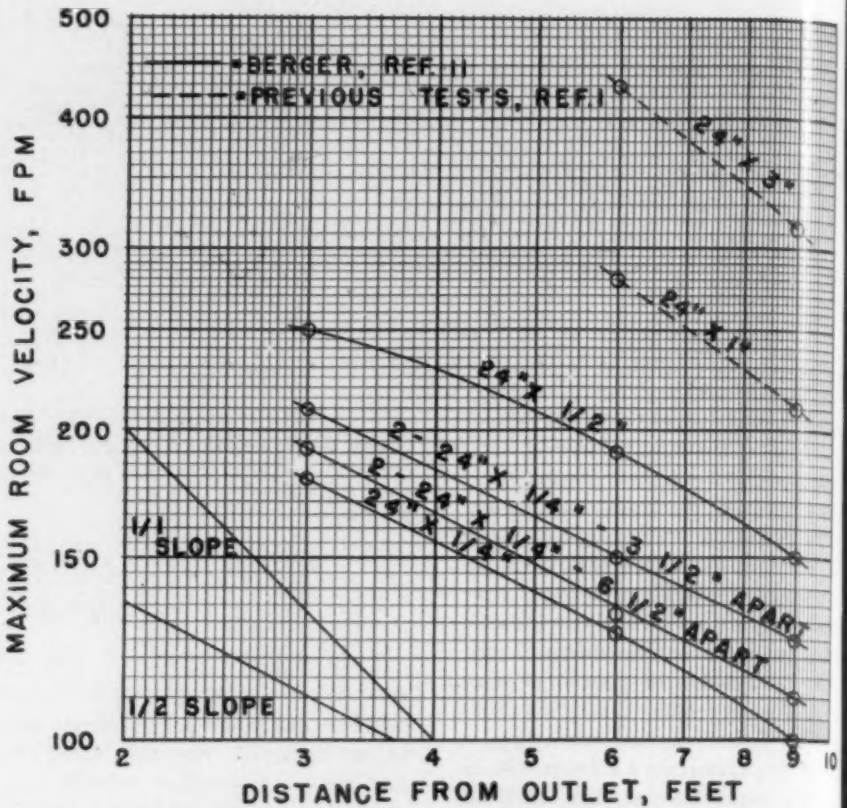

Fig. 11—Effect of slot width and spacing on entrainment ratio

Parallel Slots Above One Another

Figs. 11 and 12 show the effect of using two slot outlets, one above the other, as reported by Berger.[11] The outlet velocity (cfm/area) for Fig. 12 was 800 fpm. It is noted that if the slots are placed close together the effect is little different than if a single slot of equal area were used. The ¼ in. slots must be placed some distance greater than 6½ in. apart to get the increased entrainment effect of the single ¼ in. slot.

[11] Air Stream Characteristics of Narrow Slots, by J. A. Berger. (Thesis, Case School of Applied Science, December 1943, 63 pages.)

Applications

Following are typical examples of the application of Equation (1). These apply only to non-directional air outlets with little or no temperature difference between outlet air and room air.

Example 1:

Given: A 6-in. sq nozzle outlet delivering air at 2000 fpm face velocity.

Required: (*a*) Distance from outlet at which the maximum velocity is 100 fpm; (*b*) Distance from outlet at which the maximum velocity is 500 fpm.

Solution: (*a*) Using Equation (1*a*):

$$X = \frac{K V_o \sqrt{A_o}}{V_r}$$

From Table 2, $K = 3.7$

$V_o = 2000$. $\sqrt{A_o} = 0.5$ $V_r = 100$.

$$X = \frac{3.7 \times 2000 \times 0.5}{100} = 37 \text{ ft}$$

$$(b)\ X = \frac{6.0 \times 2000 \times 0.5}{500} = 12 \text{ ft}$$

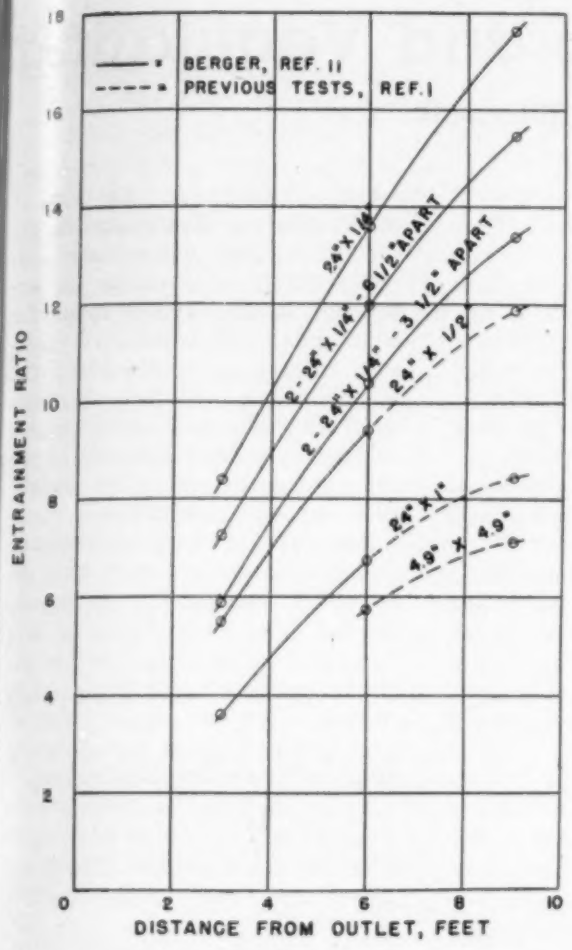

Fig. 12—Typical logarithmic graph of room velocity vs. distance, for slots; outlet velocity 800 fpm, (cfm/area)

Example 2:

Given: A square edged slot 18 in. long and 1 in. high is to deliver 300 cfm.

Required: The maximum and the average velocities in the stream at a distance of 25 ft from the outlet.

Solution: Using equation (1*b*):

$$V_r = \frac{K Q}{X\sqrt{A_o}}$$

$$A_o = \frac{18 \times 1}{144} \times 0.65 = 0.081$$

(See Table 3).

$$V_o = \frac{300}{0.081} = 3700.$$

$K = 5$ (estimated).

$X = 25.$

$$V_r = \frac{5 \times 300}{25\sqrt{0.081}} = 212.$$

Actual value of K from Table 2 is 5.2. Hence, maximum velocity at 25 ft distance is $212 \times \frac{5.2}{5} = 220$ fpm, and average velocity is $\frac{220}{3} = 73$ fpm.

Example 3:

Given: A bar-type grille of 65 per cent free area and discharge coefficient $C = 0.75$ is to be used to produce a throw of 30 ft, with a maximum residual velocity of 150 fpm. Outlet velocity (based on plenum pressure) is 1600 fpm.

Required: (*a*) Area of grille (core area); (*b*) total room air entrained in the 30-foot throw.

Solution:

(*a*) Using Equation (1*a*):

$$\sqrt{A_o} = \frac{X V_r}{K V_o}$$

$X = 30.$ $V_r = 150.$ $V_o = 1600.$

$K = 4.2$

$$A_o = \left(\frac{30 \times 150}{4.2 \times 1600}\right)^2 = 0.45 \text{ sq ft.}$$

$$\text{Core area} = \frac{0.45}{0.75} = 0.60 \text{ sq ft or } 86 \text{ sq in.}$$

(*b*) Entrainment ratio is computed from Equation (6):

$$\frac{Q_\infty - Q_o}{Q_o} = \frac{0.785 \times 4.2}{3 \times 30 \times \sqrt{0.45}}\left(\sqrt{\frac{0.45}{0.785}} + 0.35 \times 30\right)^2 - 1 = 5.92$$

$Q_o = V_o A_o = 1600 \times 0.45 = 720$ cfm.

Therefore, total room air entrained is:

$Q_\infty - Q_o = 5.92 \times 720 = 4260$ cfm.

Conclusions

The following conclusions seem to be justified, as applied to straight flow outlets up to 100 sq in. area, for outlet velocities below 7000 fpm, when the air stream is not disturbed by contact with surfaces or by adjacent streams:

1. The shape of the outlet has only a small effect on the throw of the stream as long as the aspect ratio is below 50.

2. The shape of the air stream at distances beyond 20 diameters from the outlet is not greatly affected by the shape of the outlet.

3. The performance of an air stream from an outlet depends on the "effective" area of the outlet. Effective area of a rounded-entrance outlet almost 100 per cent, but in any other case, corrections must be made by multiplying by percentage free area, and by a coefficient of discharge to account for jet contraction.

4. Beyond about 20 diameters from the outlet and as long as the maximum velocity in the stream exceeds 500 fpm, the residual velocity is almost directly proportional to the outlet velocity and inversely proportional to the distance from the outlet.

5. When the maximum residual velocity in the stream no longer exceeds 500 fpm, the velocity falls off more rapidly; hence if the usual methods of calculation are used (Equation 1), the constant of proportionality must be reduced accordingly (Table 2).

6. The numerical values to be used in the equations for air stream performance (Equations 1 to 5) will depend somewhat on the methods and instruments used for measuring the air velocities.

7. The ratio of maximum velocity to average velocity at any section of the stream beyond 10 outlet diameters is approximately 3 to 1.

8. Multiple slots, nozzles or orifices, when spaced only a few inches apart, produce an air stream that performs almost exactly like the stream from a single outlet of the same total area.

Acknowledgment

The tests reported in this paper have extended over a period of about two years, and the authors wish to thank the many persons who have assisted in carrying on the work. Special thanks are extended to the following for making large numbers of detailed observations and calculations, and plotting curves: Messrs. K. E. Wolfs, S. M. Fingerhut, S. A. Rosenbluth, J. A. Berger, R. F. Tuve and E. C. Cornell, all of the Class of 1943, Case School of Applied Science.

Fifty Years in Heating and Ventilating

By Samuel R. Lewis,* Chicago, Ill.

BASED ON my memory and on considerable reference to old text books and catalogues I found that eastern and central western practices in heating and ventilating 50 years ago had many differences in 1894.

The central west seems to have preferred single-pipe steam heating, while the east used two-pipe systems; usually with the return mains sealed below the water level in the boiler. Chicago had miles of apartment buildings all with single-pipe steam heating systems; most of them with brick set steel firebox boilers.

New York had many similar buildings, but the radiators usually had two connections and two valves, and the boilers were likely to be of sectional cast-iron type. Perhaps the early two-pipe vapor systems were developed because of the difficulties in controlling steam radiators which had two valves.

The design of cast-iron sectional boilers as of 1894 shows that heat transfer surface was sought at the expense of adequate combustion chamber height. They made the boiler so full of water passages that there was not enough space left for the burning coal.

I remember being called on to correct the heating of a large Chicago residence about 1910. The sectional boiler had water-cooled heat absorbing surfaces only 14 in. above the top of the 60-in. long grate. They could not burn enough coal to heat the house. I held the boiler up on jackscrews while I wrecked the cast-iron base and lowered the grates to give a 30-in. clearance between them and the top of the combustion chamber. Refractory lined masonry was used to form a new firebox and ashpit. The results were excellent in every way, and the old boiler serves the old house with ease and satisfaction to this day.

I remember designing the heating of two large high schools within 50 miles of New York City, about 35 years ago. The contractors seemed to know nothing about steel firebox type heating boilers such as I was accustomed to use in the west. I also remember seeing in the public schools in Elmira, New York, sectional cast-iron boilers made by the H. B. Smith Co., operating at 50 lb per sq in. pressure and furnishing steam to run the fan engines.

One large manufacturer made a very radical change in the design of cast-iron sectional boilers about 1905, cutting out most of the interior water passages and gaining combustion space at the expense of heat absorbing surface. These boilers had hot breechings and the design very quickly was modified to one in which there was a more logical balance between the two fundamental requirements.

All of the early sectional cast-iron boilers were short on steam liberating area at the water line and on interior water circulation from section to section. It is only within very recent years that the large top connecting nipple, partly below the water line was developed. With the older boilers priming usually manifested itself and much washing out of every new boiler was required. The increased steam liberating area and the coherent water circulation when the top nipples are partly below the water line have improved this matter.

Old catalogues show cast-iron sectional boilers encased in brickwork, and many round boilers equipped with steel jackets. Then steel jackets on cast-iron boilers seem to have been forgotten during many years, only to reappear in comparatively recent times with deluxe baked enamel finish.

Around the first of the century there was some question in designers' minds as to justification for use of the comparatively new vacuum system of steam heating, on which a royalty must be paid on account of patents. The Paul scheme, started in Chicago, I think, involved piping up the air vents of a single-pipe radiator system, leading to a steam jet exhauster in the boiler room for maintaining subatmospheric pressure when desired throughout the system. It improved many an otherwise sluggish and noisy steam heating plant and hundreds of the old systems still are in use, usually with improved exhausters.

Some one probably in the east, perhaps Warren Webster, then developed a trap for the return connection from each radiator on a two-pipe heating system so that the Paul separate air pipe would not be needed. This trap at first was of float type and its use was popularly believed to require that a royalty must be paid to the owner of the Paul patent. In those days there was much litigation concerning patents on subatmospheric steam heating.

The float trap had definite limitations and soon was succeeded by the vapor filled thermostatic disk and bellows type of vacuum trap which persists to this day. It is believed C. A. Dunham pioneered in the thermostatic trap.

I have a data book which was published in 1895. It carries advertisements of the principal manufacturers of heating and ventilating equipment. It gives the amount of direct radiation alleged to be necessary at various rates per square foot of glass surface, or per square foot of wall surface or per cubic foot of contents of a room. It is careful not to suggest the most approved rate, but one example cites 1 sq ft of radiation for 37.5 cu ft contents.

I know that in those days no one did much Btu work, but generally used the formula ascribed to Mills for steam, which was:

1 sq ft of radiation for each 2 sq ft of glass in outside walls, plus 1 sq ft of radiation for each 20 sq ft of exposed wall (deducting the square feet of glass) plus 1 sq ft of radiation for each 200 cu ft in the room.

For ordinary thermally circulated hot water radiation the fac-

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For presentation at the Annual Meeting of the American Society of Heating and Ventilating Engineers, New York, N. Y., January 1944.

tors changed to 2, 10 and 60 respectively. Like many old housewife medicines, this rule of thumb checks very well with the average of more scientific formulas.

Some of the Bundy radiators of 1894 were arranged for cast-iron or marble flat top plates. These radiators were made of cored cast-iron tubes screwed into cast-iron bases. They are rarely seen these days. All sectional radiators definitely had to be ordered as for steam, with bottom connecting nipples only, or for water, with both top and bottom nipples. It was believed then that a water radiator would not work if used with steam; the contrary fact not having been discovered until passage of many years after 1894.

A good deal of emphasis seems to have been given to flue type radiators, some having vertical solid flanges, while others had curved flanges intended to encourage reception of air by the radiator in a vertical up-going stream with delivery from the face of the radiator in a horizontal direction.

One rarely sees a dining room radiator having shelves for warming the dinner plates and coffee cups behind cast-iron doors, although they were popular in the nineties.

There were long arguments about how to measure the radiating surface of an ornamental cast-iron radiator and rival manufacturers questioned the methods of measurement by their competitors. As far as I can learn it was not until well along in the present century that the obvious fact occurred to any one that each 144 sq in. of surface in a radiator gives off heat at widely varying rates depending on a great many factors. End sections being exposed to free air circulation condense more steam than interior sections. The upper areas of tall radiators never see any air but that which already has been warmed by surfaces lower down. Wide radiators heat much less air per unit of surface than do narrow ones. Steam in one large tube heats less air than when in several small tubes in the same space.

The radiator manufacturers of 50 years ago seem to have been in some agreement that a radiator might be a beautiful thing if sufficiently ornamental. One can be thankful that we have emerged from that Victorian era to the present plain, thin tube, low height type of radiator.

I cannot feel that with the present enclosed, thermally circulated convector we are making progress. For efficiency in transferring dust from the floor to the wall, and for effective laying down on the job when the heating medium within it is only warm and not hot, the finned tube convector of around 1940 is unsurpassed. I vote to consign it to the limbo of forgotten things along with such names as I can cull from the old catalogue as follows:

Volunteer, All Right, Commonwealth, Hecla, Mascot, OK, Hub, Economy, Novelty, Sunray, Cataract, Faultless, Royal, Electric, Tropic, Perfect, Modern, Florida, Advance, Little Giant, Imperial, Champion, Joy, Crescent, Climax, Elite, Cyclonic.

Steam convectors in 1894, where used with mechanically circulated air, almost universally were made of 1-in. pipe screwed into cast-iron headers or bases. There was talk about that time of a new cored cast-iron prime surface convector which was to be called Vento.

All of the original convectors were difficult to vent, especially when applied to vacuum systems. Frequently the older cast-iron extended surface convectors which had been used for years with thermally circulating air, were installed in fan systems. These are no longer made except under protest. They had round pins and thin flanges and carried such names as Perfection and Excelsior and Gold.

The pipe coil fan system convectors were built in many types. One had pairs of pipe from a double chambered horizontal box base connected at the top with return bends. Another used two cast-iron headers, one as a base, for condensate and one at one side, vertically disposed, as steam supply. The Chicago schools used a special base for many years in which the steam supply came vertically through the bottom of the single chambered base casting.

Any old time steam fitter will remember the fun he had when converting some of these old pipe coil convectors originally installed for pressure service, to drain and to vent under more modern vacuum system conditions.

When Vento blast radiation came along early in the century, some research and experimenting on the jobs, in which I had no small part, had to be encountered before the correct air venting technique was developed. Cast-iron convectors, such as Vento, do not freeze so quickly as do the more flashy thin tube, wide flanged, present day convectors, but the great weight of cast-iron gradually may cause its retirement. One may predict much future trouble with the present day convectors, made of thin steel substituted by emergency for the everlasting copper of prewar days.

Fans in 1894 were of the eight-blade, centrifugal or radial flow type, with straight blades. In selecting one of these devices from the manufacturer's rating, there was always a discount for optimism of from 40 to 60 per cent. The modern, narrow multiblade fan wheel had not been imported (I think it came from Ireland).

There had been little research on fan efficiencies and all radial flow fans had small outlets and chaotic delivery velocities at various spots across these outlets. If perchance a fan after installation, proved too small, additional steel plates could be bolted to the outer edges of the paddles, thus increasing the diameter and the noise and the power. Not much was said in catalogues about the volume and power at various resistances.

There were axial flow fans of flat disk type and of propeller type, but it was known that they were not of much use in heating systems because of failure to overcome the resistance due to heaters and long ducts.

There was little knowledge yet developed concerning refinement of centrifugal fan inlet rings, various curves in blades, etc. Research along these lines still continues, and if one can believe the advertisements there will emerge for general use, after the war, great improvement in axial-flow pressure type fans.

Warm air heating by direct coal-fired cast-iron furnaces was well developed in 1894, especially for

school buildings. While thermally circulated air was used for the smaller schools, many larger school buildings were heated by mechanically circulated air.

Electric central station energy was by no means universal, and power for operating fans frequently was developed by gasoline and gas engines. For example around 1900, the large high school in Kansas City, Kan., had 12 cast-iron furnaces and a 25 hp gasoline engine. The centrifugal type blower created a pressure around the furnaces and forced the air into two separate masonry plenum chambers, in one of which the air temperature was kept at about 130 F; and the temperature in the other at about 60 F. The lower temperature was maintained by mixing a part of the unheated outside air with heated air through interconnected double dampers under thermostatic control. A separate single duct ran from these chambers to each classroom, having at its inlet double dampers each of which responded to a thermostat in the respective room.

This scheme has been revived during the present war emergency, under pressure of the Washington authorities, for use in many community buildings of housing projects.

Steam, all-blast heating was developed and in wide use 50 years ago following the general scheme described for warm air furnaces in school buildings; particularly in the schools of Chicago, St. Louis, and Kansas City, and this system persists in modified form.

There was a steam convector called a tempering coil through which air from out of doors was drawn to the supply fan. Temperature control was obtained by a single blade by-pass damper around the tempering convector, permitting a graduated mixing of the two air streams to maintain the desired condition in the cooler of two plenum chambers. The fan forced this air through additional steam heated convectors into the warmer plenum chamber and from these two a separate air duct with thermostatically controlled mixing dampers supplied each room. The all-blast steam heating system used an engine for fan power and the exhaust steam from the engine was condensed in the convectors.

The early custom was to confine this economizer action to one section or layer of the tempering convector in contact with the coldest air, but later practice was to install an oil separator and a pressure reducing valve and thus by providing a relatively low pressure in the heat transfer surfaces, to permit condensing all of the exhaust steam regardless of outside air temperature.

As electric energy became available with passage of the years the steam driven engines and pumps gradually have lost popularity and in most school building heating practice of today the fans and vacuum pumps are electric driven, and the plants can be attended by engineers of somewhat less skill and experience than was required with relatively high pressure power plants.

In some cities, particularly in the eastern part of the United States, the combined heating and ventilating plants in school buildings operated on a split system basis and continue to do so. In such an arrangement enough direct radiation is installed in each room to heat the room, while air at one temperature is forced by fans to all the rooms regardless of orientation or local heat sources. Such systems of heating usually were less economical of fuel than were the all-blast systems. This loss was occasioned partly because of greater heat transfer due to hot radiators against cold outside walls, partly because of less effective temperature control due to time lag in cooling the hot radiators and partly because the radiation in the first room to reach the desired temperature could not be utilized to help heat the remaining too-cool rooms.

With an all-blast system on the other hand, when the first room became warm enough the heat from the radiation which had accomplished it, this radiation being piled up near the fan, automatically was diverted to the remaining rooms.

When electric energy for driving fans became universally available, the very large central air supply fans and piled-up convectors, with exceedingly long separate air ducts running out to the rooms, were superseded by several smaller systems each with comparatively short ducts. This tendency in large buildings toward use of several smaller systems with heating convectors close to the rooms commenced about 1908 in many school buildings.

One of the first unit heaters was patented back in the seventies by B. F. Sturtevant using a centrifugal fan and pipe convector but was not in general use until early in the present century. The present propeller type unit heater seems to have been inspired by an automobile engine-cooling hot water radiator.

Hot water heating in 1894 was largely obtained by thermal circulation. The designing and installation required considerable skill, with delicate adjustments of the pitch of the take-off tees from mains so as to balance circulation. The mains were very large as compared with present custom. One New York City concern, Evans-Almirall Co., did practice the rudiments of forced circulation hot water as is known today, but worked on a relatively low differential pressure, the mechanical circulation applying only to the mains, with thermal circulation for all branches and risers, and generally using an open expansion tank. This concern installed many large central station heating systems and was an outstanding pioneer in hot water heating. They developed fundamentally correct scientific methods for computing pipe sizes and temperature differentials.

The central heating plant at Ohio State University is an outstanding example of an early hot water heating system, in which the heat in exhaust steam from the electric generating plant is transferred to the hot water. This permits transmission of heat in underground mains to distant buildings without necessity for high back pressure at the exhaust steam outlets of the power plant.

Automatic temperature control in 1894 was obtained largely by use of compressed air thermostats. The first successful automatic temperature regulating system seems to have been by a combination of direct current electricity with compressed air, but the electric equip-

ment of those days was unreliable, and by 1894 had been superseded by all-pneumatic systems.

The modern all-electric systems have been developed during the past 20 years. The present tendency seems to be to return more and more to a combination of both electric energy and compressed air, especially in the many complicated duties required when use of refrigeration and control of relative humidity enter the picture.

Civilization seems to move in cycles and heating processes and methods seem to follow the same principle. Thus the underfeed coal stoker was old, fell into disrepute and became almost obsolete, only to be revived when the simple, worm-feed principle appeared. Spreader type stokers were used successfully 40 or more years ago and were almost forgotten only to stage a comeback which still is accelerating. Down-draft manual firing of boilers and furnaces was almost extinct when Kewanee brought out the successful down-draft steel firebox boiler, which in turn was to be outmoded by the revived underfeed stoker and by the oil burner which atomized the fuel. There is evidence that, all things considered, a big down-draft, manually fired heating boiler burning bituminous coal can set an efficiency mark which other fuels and methods do not easily surpass.

F. Paul Anderson Award

to

Dr. Ferry C. Houghten

Ferry C. Houghten

Dr. Ferry C. Houghten, now on active duty in the U. S. Navy with the rank of Lieutenant Commander, has been awarded the F. Paul Anderson Medal of the American Society of Heating and Ventilating Engineers. The award is made to Dr. Houghten, "For outstanding research over a long period of years in the fields of heating, ventilating and air conditioning, resulting in distinct benefits to the public and the nation; for advancement of the knowledge of the physiological reactions of persons to their environment; and for the careful presentation of technical data readily adaptable to general use in engineering."

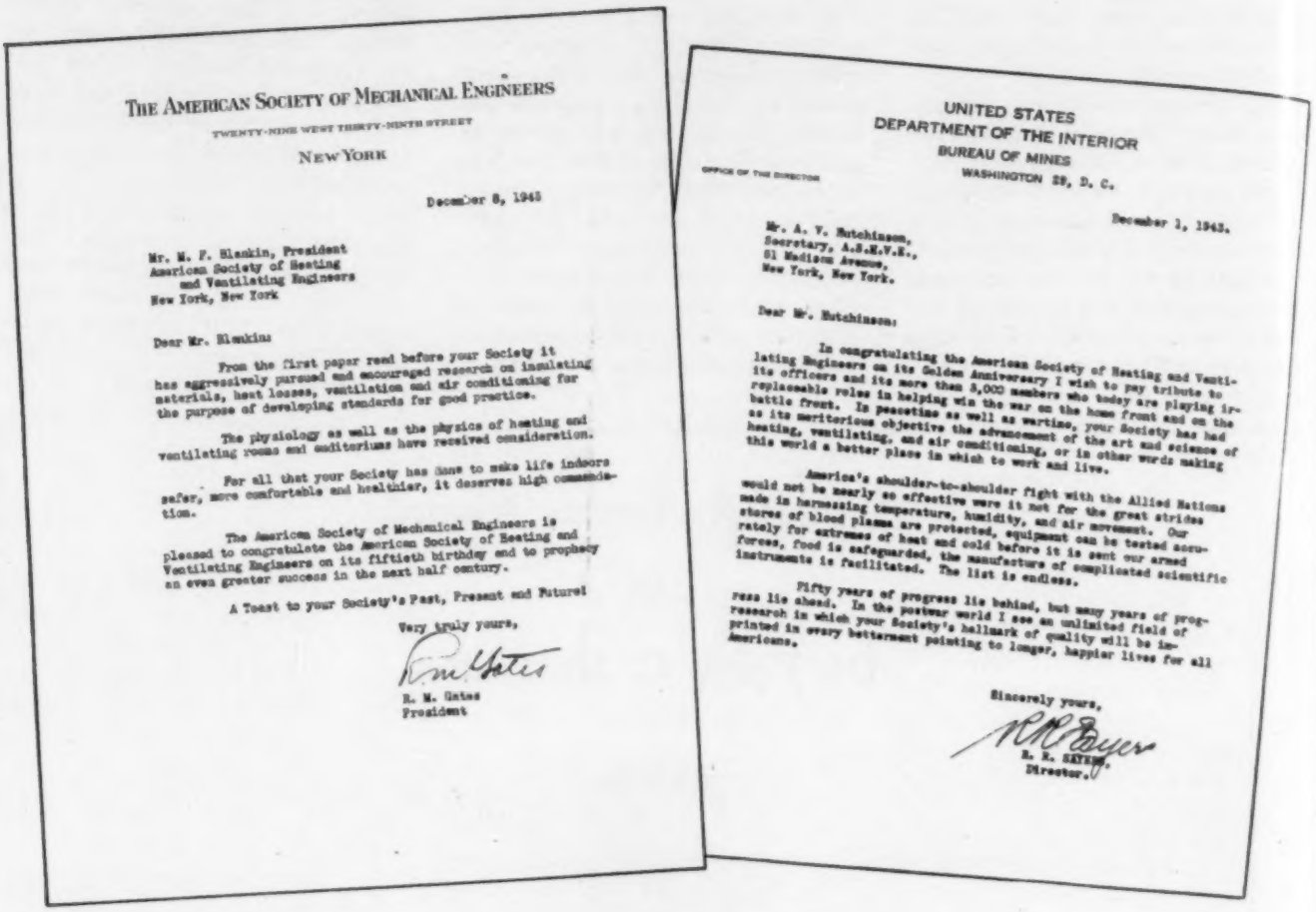
The presentation of the medal is to be made by Pres. M. F. Blankin on Wednesday, February 2, during the 50th Annual Meeting of the Society at the Hotel Pennsylvania, New York.

The F. Paul Anderson medal was founded in 1930 in honor of Dean F. Paul Anderson, Dean of Engineering, University of Kentucky, to be awarded "in recognition of notable scientific achievement or outstanding services performed in the field of heating, ventilating or air conditioning."

The award has previously been conferred upon Dr. Willis H. Carrier, Syracuse, N. Y., in 1932; Dr. Arthur C. Willard, Urbana, Ill., in 1936; Prof. F. B. Rowley, Minneapolis, Minn., in 1939; and to Dr. F. E. Giesecke, College Station, Tex., in 1942.

Dr. Houghten was born in Troy, Mich., in 1888, and after graduation from Olivet College in 1913 with an A. B. degree, he received a Master of Science Degree at the University of Washington in 1915. After teaching science for a period of three years he joined the staff of the U. S. Bureau of Mines, Pittsburgh, where he carried on research in fuel utilization. He became associated with the Research Laboratory of the Society in 1920 and then served as Secretary of the Society in 1924 and 1925. In September 1925 he returned to the Research Laboratory as its Director and remained in this capacity until April 1942, when he was called for active duty in the Bureau of Ships of the U. S. Navy.

In February 1941, Dr. Houghten was awarded an honorary degree of Doctor of Science by Olivet College, Olivet, Mich., at its Annual Founders' Day Convocation. Dr. Houghten is the author of many papers which appear in the ASHVE Transactions and he has contributed numerous scientific articles to publications in the engineering and medical fields.



THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

TWENTY-NINE WEST THIRTY-NINTH STREET

NEW YORK

December 8, 1943

Mr. H. F. Blankin, President
American Society of Heating
and Ventilating Engineers
New York, New York

Dear Mr. Blankin:

From the first paper read before your Society it has aggressively pursued and encouraged research on insulating materials, heat losses, ventilation and air conditioning for the purpose of developing standards for good practice.

The physiology as well as the physics of heating and ventilating rooms and auditoriums have received consideration.

For all that your Society has done to make life indoors safer, more comfortable and healthier, it deserves high commendation.

The American Society of Mechanical Engineers is pleased to congratulate the American Society of Heating and Ventilating Engineers on its fiftieth birthday and to prophesy an even greater success in the next half century.

A Toast to your Society's Past, Present and Future!

Very truly yours,

R. M. Gates
President

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES

OFFICE OF THE DIRECTOR

WASHINGTON 25, D. C.

December 1, 1943.

Mr. A. V. Hutchinson,
Secretary, A.S.H.V.E.,
51 Madison Avenue,
New York, New York.

Dear Mr. Hutchinson:

In congratulating the American Society of Heating and Ventilating Engineers on its Golden Anniversary I wish to pay tribute to its officers and its more than 8,000 members who today are playing irreplaceable roles in helping win the war on the home front and on the battle front. In peacetime as well as wartime, your Society has had as its meritorious objective the advancement of the art and science of heating, ventilating, and air conditioning, or in other words making this world a better place in which to work and live.

America's shoulder-to-shoulder fight with the Allied Nations would not be nearly so effective were it not for the great strides made in harnessing temperature, humidity, and air movement. Our stores of blood plasma are protected, equipment can be tested accurately for extremes of heat and cold before it is sent our armed forces, food is safeguarded, the manufacture of complicated scientific instruments is facilitated. The list is endless.

Fifty years of progress lie behind, but many years of progress lie ahead. In the postwar world I see an unlimited field of research in which your Society's hallmark of quality will be imprinted in every betterment pointing to longer, happier lives for all Americans.

Sincerely yours,

R. R. SAYERS,
Director.

Greetings for Our Golden Anniversary

From Engineering Society of Detroit—To the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS on its Fiftieth Anniversary The Engineering Society of Detroit sends cordial greetings and hearty congratulations.

Your past is a splendid record of service and achievement; in the present your members are doing their full share toward winning the war; for the future you have a unique opportunity to contribute still more toward human health and comfort.

We are proud to have your Michigan Chapter as one of our Affiliate Groups and have appreciated its contributions to our Society and to the engineering life of this community.

We salute you.

From Kiwanis International, Chicago—The success of America's war effort depends to a great extent on the strength of its home front.

For 50 years the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS has contributed mightily to the creation of a strong home front by drawing plans and specifications and devising equipment intended to keep houses and buildings warm, insulated and healthful with conditioned air.

When the United States declared war against the axis nations, the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS immediately turned its attention to the production of armaments.

Kiwanis International, with its 2200 clubs and 125,000 members, joins the parade of organizations extending congratulations and good wishes to the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS on its Golden Anniversary.

Since the establishment of your Society in 1894, your members have blazed a historic trail that is recognized the world over. From the days of imperfectly heated and ventilated homes and buildings, your organization has designed equipment that has brought comfort, joy and happiness to every household and office.

The AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS has enjoyed a glorious past, but its future offers possibilities that are far-reaching. When the United Nations have successfully concluded the war, America immediately will begin thinking in terms of peace-time goods and reconversion will find home and building construction increasing by leaps and bounds.

The AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS will not miss this opportunity to continue its great work of the past and to further develop and improve the technical equipment so vital to every American.

Kiwanis International maintains that America's future is secure. Its best wishes go to the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS in war and in peace.

From Arno C. Fieldner, Chief, Fuels and Explosives Service, United States Department of the Interior, Bureau of Mines—Greetings to the officers and members of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS on this happy occasion of the commemoration of your Golden Anniversary. It marks the passing of a half century of very practical service to the American people in providing one of the primary needs of existence, namely, the maintenance of a comfortable temperature and healthful atmospheric conditions in homes and working places as well as in public buildings where people congregate. The work of the Society is related intimately to the everyday

life of the average person and he has benefited greatly from its work.

My personal contact with the Society began with the establishment of the Research Laboratory at the Central Experiment Station of the Bureau of Mines at Pittsburgh, Pa. It was my privilege to take part in behalf of the Bureau in cooperative research problems with the laboratory staff, first under the pioneering direction of Dean John R. Allen and then under the genial direction of Dean F. Paul Anderson and subsequently under the direction of F. C. Houghten, now a Lieutenant Commander in the Navy. The most important fruits of this cooperation were the famous comfort charts of the Society, which have had widespread recognition as showing in convenient and usable form the effect of temperature, humidity, and air movement on the comfort and physiological condition of persons working or at rest under various combinations of these factors. The results of this investigation were of special value to the mining industry because of the high temperature and high humidity prevailing in many deep mines, which called for special measures to ameliorate these trying conditions for the workers in these mines. The mining industry also owes much to one of your distinguished members, Willis H. Carrier, and his associates for developing mechanical methods of conditioning the atmosphere in very deep mines, thus making it possible to recover valuable minerals at depths where formerly it would have been impossible to conduct operations on account of the high temperature and high humidity in the working places.

The studies in the psychrometric chambers at Pittsburgh have been of wide usefulness in homes, in many industries, and in naval warfare. They illustrate the fundamental interest of the members of the Society in the technical advancement of their profession and their desire to contribute to the general welfare.

I am most happy to send these greetings and to extend my best wishes for the future.

Fiftieth Birthday of ASHVE

January 31 - February 2 **Hotel Pennsylvania, New York**

1894
A GREAT PAST

A GREATER FUTURE
1944

MEMBERS of the Society will gather from all parts of the country for the 50th Annual Meeting, which is scheduled for January 31, February 1 and 2, 1944, at Hotel Pennsylvania, New York. In addition to commemorating the Society's 50th year of service, 1944 also marks the 25th anniversary of the establishment of the Society's Research Laboratory.

Early arrivals will attend committee meetings on January 30 and the first business session will open Monday the 31st. In addition to the reports of officers and regular committees, there will also be a special report by the Chapter Development Committee which was appointed last June. Changes in the Research Regulations made necessary by the expanded scope of the research program must also be considered.

The Committee on Arrangements of the New York Chapter has announced the following special functions: Monday at noon, get-together luncheon for members and ladies; Monday evening, a demonstration and discussion of the fascinating subject of Electronics by Samuel Hibben, followed by the Oldtimers' Reunion; and on Wednesday the Annual Banquet, at which Pres. M. F. Blankin will present the F. Paul Anderson Medal to Lt. Comdr. F. C. Houghten, USNR. Program details will be found on the following pages.

The Committee on Arrangements desires to provide for the comfort of visiting members and because of present conditions faced by transportation lines and hotels, suggests making early hotel reservations, purchase of railroad tickets as soon as possible and preferably two or three weeks in advance of the meeting, and travel with a minimum amount of personal baggage.

Because of rationing, it is essential that advance reservations be made for the opening luncheon, the oldtimers' reunion and the annual banquet.

A. J. Offner, General Chairman of Committee on Arrangements, states that New York members are ready to extend a hearty welcome to those who are planning to attend the Golden Anniversary Meeting of the Society. He points out that the Society has had a great past and is looking forward to a greater future.

Travel Time

To New York

From	By Rail	By Plane
Boston	4½ hrs	1¼ hrs
Philadelphia	1½ hrs	50 min
Washington	3 hrs 35 min	1½ hrs
Pittsburgh	8 hrs 50 min	2 hrs 14 min
Cleveland	11½ hrs	2¾ hrs
Cincinnati	15 hrs	4½ hrs
Detroit	13 hrs	3½ hrs
Chicago	15 hrs	3¾ hrs
Indianapolis	15 hrs	4¼ hrs
St. Louis	25½ hrs	6 hrs
Toronto	12 hrs	.....
Montreal	9 hrs	2 hrs

Secure your tickets for the round trip before leaving home.

1894 1944

Alfred J. Offner
General Chairman

COMMITTEE ON ARRANGEMENTS

Alfred J. Offner, *General Chairman*

Honorary Chairmen—Homer Addams, W. H. Carrier, W. H. Driscoll, W. L. Fleisher, D. D. Kimball.

Vice-Chairmen—R. H. Carpenter, J. C. Fitts, W. E. Heibel, C. S. Koehler, A. E. Stacey, Jr., R. A. Wasson.

Banquet—Alfred Engle, *Chairman;* Russell Donnelly, *Vice-Chairman;* E. E. Ashley, R. W. Cumming, M. C. Giannini, Joseph Wheeler, Jr.

Finance—W. M. Heebner, *Chairman;* H. W. Fiedler, *Vice-Chairman;* R. R. Ferguson, G. E. Olsen.

Hospitality—H. S. Wheller, *Chairman;* W. J. Olvany, *Vice-Chairman;* T. N. Adlam, F. E. W. Beebe, H. H. Bond, Ernst Graber, E. B. Johnson, C. A. Miller, L. L. Munier, J. R. Murphy.

Inspection—C. S. Pabst, *Chairman;* P. B. Gordon, *Vice-Chairman;* H. L. Alt, J. A. Heller, M. H. Hirsch, F. D. Lawrence, Rudolph Pollak.

Ladies—Mr. and Mrs. H. J. Ryan, *Co-Chairmen;* H. S. Johnson, Mrs. R. H. Carpenter, Mrs. H. W. Fiedler, Mrs. W. L. Fleisher, Mrs. O. E. Frank, Mrs. A. V. Hutchinson, Mrs. C. S. Koehler, Mrs. G. E. Olsen, Mrs. R. A. Wasson.

N. Y. Chapter Special Committee—C. F. Roth, *Chairman;* J. G. Eadie, J. C. Fitts, C. S. Hoffman, H. C. Meyer, Jr., G. M. Scott.

Publicity—R. V. Sawhill, *Chairman;* Clifford Strock, *Vice-Chairman;* A. A. Bearman, C. H. B. Hotchkiss, O. O. Oaks, W. J. Osborn.

Sessions—E. J. Ritchie, *Chairman;* C. H. Flink, *Vice-Chairman;* E. E. Adams, S. R. Apt, Thomas Baker, P. G. Griess, G. D. Guler, C. R. Hiers, H. P. Waechter.

Special Events—A. C. Buensod, *Chairman;* A. F. Hinrichsen, *Vice-Chairman;* V. J. Cucci, C. A. Fuller, F. D. McCann, M. F. Rather, H. J. Rose, W. A. Sherbrooke.

Alfred Engle
Chairman
Banquet

W. M. Heebner
Chairman
Finance

H. S. Wheller
Chairman
Hospitality

A. C. Buensod
Chairman
Special Events

C. F. Roth
Chairman
N. Y. Chapter Special Committee

R. V. Sawhill
Chairman
Publicity

A GREAT PAST **A GREATER FUTURE**

C. S. Pabst
Chairman
Inspection

Mrs. H. J. Ryan

H. J. Ryan

Co-Chairmen
Ladies' Committee

E. J. Ritchie
Chairman
Sessions

PROGRAM

Hotel Pennsylvania, New York, N. Y.
January 31-February 1-2, 1944

Sunday, January 30

10:00 a.m. Meeting of 1943 Committee on Research
1:00 p.m. Registration—Ballroom Foyer
1:30 p.m. Council Meeting

Monday, January 31

8:30 a.m. Registration—Ballroom Foyer
9:30 a.m. BUSINESS SESSION—Georgian Room
Greetings
Anniversary Messages from other Organizations
Introduction of Guests
Reports of Officers and Council
Report of Chapter Development Committee, W. A. Russell, *Chairman*
Report of Committee on Research, C. M. Ashley, *Chairman*
Report of Guide Publication Committee, P. D. Close, *Chairman*
Amendments to By-Laws
Report of Tellers of Election
12:30 p.m.—Get-together Luncheon—Grand Ballroom
2:00 p.m. TECHNICAL SESSION—Georgian Room
The Theories and Practices of the Past Fifty Years in Heating and Ventilation, by S. R. Lewis
Review of the Development of Standards for Comfort Air Conditioning, by Lt.-Comdr. F. C. Houghten
Panel Discussion: The Future Trends of Heating, Ventilating and Air Conditioning
4:00 p.m. Technical Advisory Committee on Corrosion Joint Meeting
4:30 p.m. Joint Meeting, Technical Advisory Committee on Radiation and Comfort and Committee on Instruments
6:30 p.m. Past Presidents' Dinner
7:30 p.m. Technical Advisory Committee on Weather Design Conditions
Technical Advisory Committee on Sound Control
Technical Advisory Committee on Heat Requirements of Buildings
Technical Advisory Committee on Air Conditioning Requirements of Glass
8:30 p.m. Tomorrow's Uses of Radiant Energy, by Dr. Samuel G. Hibben—Salle Moderne
(Inter-woven into the developing science of electronics are many intriguing uses of radiant energy or strange kinds of light for other than seeing purposes. These largely unused portions of the radiant energy spectrum may develop into valuable tools for completing tomorrow's jobs.)
9:00 p.m. Old Timers Reunion—Roof Garden

Tuesday, February 1

9:30 a.m. TECHNICAL SESSION—Georgian Room
Intermittent Heating and Ventilating of Large Churches, by F. E. Giesecke
The Resistance to Heat Flow Through Finned Tubing, by W. H. Carrier and S. W. Anderson
The Control of Air Streams in Large Spaces, by G. L. Tuve and G. B. Priester
11:45 a.m.—Leave Hotel Pennsylvania for Inspection of Mechanical Equipment of Radio City
2:00 p.m. TECHNICAL SESSION—Georgian Room
Discoloration Methods of Rating Air Filters, by F. B. Rowley and R. C. Jordan
The Axial Flow Fan and Its Place in Ventilation, by W. R. Heath and A. E. Criqui
4:30 p.m. Chapter Delegates Conference
Technical Advisory Committee on Evaporative Condensors and Cooling Towers
Technical Advisory Committee on Cooling Load in Summer Air Conditioning
Joint Meeting of Technical Advisory Committees on Sensations of Comfort and Physiological Reactions
Technical Advisory Committee on Removal of Atmospheric Impurities
Technical Advisory Committee on Fuels
7:30 p.m. Organization Meeting Committee on Research
8:00 p.m. Nominating Committee meeting

Wednesday, February 2

9:30 a.m. TECHNICAL SESSION—Georgian Room
Fuel Economy in Army Heating and Power Plants, by Major Arthur W. Nelson, C. E.
Collective Bargaining for Engineering Employees, by George T. Seabury, Secretary, ASCE
2:00 p.m. TECHNICAL SESSION—Georgian Room
Optimum Surface Distribution in Panel Heating and Cooling Systems, by B. F. Raber and F. W. Hutchinson
Unfinished Business
New Business—Resolutions
Installation of Officers
Adjournment
7:00 p.m. ANNUAL BANQUET—Grand Ballroom
Toastmaster—W. H. Driscoll
Presentation of Past President's Emblem to M. F. Blankin
Presentation of F. Paul Anderson Medal

Thursday, February 3

10:00 a.m. Organization Meeting of Council

Method of Choosing Location of, Financing and Conducting Meetings of the Society

Resolved: That inasmuch as the Annual and Semi-Annual Meetings of the Society come under the jurisdiction of the Council, the following rules governing the handling of such meetings be adopted by the Council and published in the JOURNAL of the Society at least twice during every year, preferably just prior to each meeting.

1—The Council will select the city in which the Annual or Semi-Annual Meeting is to be held, giving due consideration to the invitations received from Chapters or members as well as to the advisability of so distributing those meetings as to make them of the greatest advantage to the general membership, and to reduce as far as possible the expense of members attending.
2—That an appropriation be made to cover the entertainment or local expenses, incurred in connection with the meeting not exceeding $500.00, the regular meeting expense to be taken care of by the General Fund of the Society in the regular way.
3—That no registration fee or compulsory obligations of any nature be imposed on members or guests.
4—That the purchase of tickets for banquets or for any other form of entertainment that may be provided be entirely voluntary.
5—That the grouping of features and the sale of tickets for group features be discouraged.
6—That the raising of funds from manufacturers of heating apparatus be discouraged.
7—That the display of samples, or of literature, advertising the product of any manufacturer in any way, shape or form, be not permitted at the booths, registration desk, or in or about the meetings.
8—That the distribution of trade papers be entirely at the discretion of the committee in charge.
9—That the local Chapter or local members be empowered to form a General Committee with such sub-committees as may be required to handle the details of transportation, hotel accommodations, entertainment, finance, etc., and that this General Committee be requested to confer frequently with the Council, through the Secretary of the Society, and to make frequent reports on progress in connection with the various matters being handled by them.
10—That the arrangements of elaborate and costly entertainment features be discouraged.
Adopted at Council Meeting, January 29, 1926.

SUMMARY OF LOCAL CHAPTER MEETINGS

Chapter	Meeting Date	Subject	Speakers	Other Features	Attendance	Attendance Ratio*
Delta	Nov. 9	The Forgotten Man	C. N. O'Day, assisted by George Hatch, both of Air Devices, Inc., New York	Murray-Wagner Bill presented by W. H. Grant, Jr. Film on "The Inside of Arc Welding"	24	0.65
Illinois	Nov. 8	Need for and Methods of Dust Control in Many Types of Industrial Plants	John M. Kane, American Air Filter Co., Louisville, Ky.	C. E. Price and A. O. May named Illinois Chapter Delegates to Chicago Technical Societies Council	80	0.55
		New Illinois Code on Sanitation	Discussed by James Allan	John Howatt reported for engineering advisory committee on Fuel Conservation		
Iowa	Nov. 9	Weather Service Available to Engineers	S. E. Decker, Des Moines office of U. S. Weather Bureau	Vice-Pres. W. W. Stuart requested members from Ames to extend sympathy of Chapter and hope for Prof. R. A. Norman's quick recovery	18	0.75
Kansas City	Nov. 22	Movie on "The Ramparts We Build"	C. G. Roush, Westinghouse Electric and Mfg. Co.	Pres. L. T. Mart discusses Fuel Conservation	39	0.70
Massachusetts	Nov. 16	Forecasting the Weather	Lyndon T. Rodgers, Senior Forecaster, U. S. Weather Bureau		15	0.26
Michigan	Nov. 16	Fuel Situation—and What to Do About It	Howard Coonley, Dir., Conservation Div., War Production Board	The Battle of Midway—colored movie Joint meeting with Engineering Society of Detroit	58	0.50
Minnesota	Nov. 20	Get-together for members, wives and guests at the Covered Wagon		D. B. Anderson submitted his resignation as president, to become Lt. (j.g.) in the U. S. Navy Mr. Anderson will remain as president for balance of year with F. W. Legler as Acting President	66	0.69
	Oct. 11	The Society's Activities in Wartime	Pres. M. F. Blankin, Philadelphia, Pa.	Reports submitted by chairmen of Entertainment and Membership Committees	50	0.53
Montreal	Nov. 17	Function of an Engineering Society in Wartime	Pres. M. F. Blankin, Philadelphia, Pa.	Nominating Committee appointed as follows: T. H. Worthington, Chm., C. W. Johnson, A. F. LaMontagne	30	0.46
Nebraska	Nov. 10	Calculation, Design, and Installation Methods for Radiant Heating	C. A. Hawk, Jr., Engineering Service Dept., A. M. Byers Co., Pittsburgh, Pa.		30	0.40
New York	Nov. 15	Flow of Air and Gases in Various Systems	S. H. Downs, First Vice-President of ASHVE, Kalamazoo, Mich.	H. W. Fiedler reported that Major J. G. Foster has been awarded the Purple Heart, the Distinguished Service Medal, and several Oak Leaf Clusters	51	0.31

Chapter	Meeting Date	Subject	Speakers	Other Features	Attendance	Attendance Ratio*
Northern Ohio	Nov. 8	The Society's Part in Wartime Work	Pres. M. F. Blankin, Philadelphia, Pa.	Program Committee chairman announced its schedule Attendance and Publicity Committee chairmen also reported	45	0.63
Oklahoma	Nov. 16	Post War and Industry	A. D. Engle, Dir. of Research, Austin Co.	As result of Pres. Blankin's visit six guests expressed interest in joining ASHVE as their contribution to Society's research Election announced: Pres. E. T. P. Ellingson, Vice-Pres. R. G. Dolan, and Sec'y Earl W. Gray	21	1.90
Oregon	Nov. 4	Fuels for Sawdust Burners	E. C. Willey, Asst. Prof. of Mech. Engrg., Oregon State College	T. E. Taylor reported on Fuel Rationing Nominating Committee announced: A. E. Finlay, Chm., J. J. Byrne, H. K. Mead, E. A. Ponder, F. F. Urban	18	0.38
	Oct. 7	Inspection trip through shipyard to view a newly completed tanker scheduled for trial run following day	B. W. Farnes introduced Messrs. Howells and Fredericks who acted as guides	Inspected boiler erection shop, where boiler construction was explained by Mr. Smith of Combustion Engrg. Co.	20	0.42
Pacific Northwest	Nov. 10	A talking picture, "Fortress in the Skies" The Wind Tunnel at the University of Washington	Boeing Aircraft Co., Seattle E. O. Eastwood, Past President of ASHVE		31	0.40
	Oct. 6	Problems in Fuel Oil Rationing	L. V. Halverson, Repr., Fuel Div., Office of OPA, Seattle, Wash.	Program Committee Chairman announced future plans A New Voice for Mr. X (movie) provided by Pacific Telephone and Telegraph Co.	21	0.23
Philadelphia	Nov. 11	Radiant or Panel Heating	Harry K. King, A. M. Byers Co.	Nominating Committee announced as follows: C. F. Dietz, H. B. Hedges, J. H. Hucker, L. P. Hynes, H. H. Mather	66	0.55
Pittsburgh	Dec. 13	Industrial Hygiene	W. C. L. Hemeon, Vtg. Engr. of Industrial Hygiene, Mellon Institute	E. C. Evans, Aerofin Corp., Cleveland, Ohio, was welcomed as a guest	19	0.29
	Nov. 8	Fuel Conservation Conservation of Fuel in the Boiler or Furnace Room How to Save Fuel "Upstairs" Fuel Conservation from the Building Operator's Point of View	W. H. Longstaff, Dist. Repr., Pittsburgh office of OPA Supt., Bureau of Smoke Prevention J. F. Collins, Jr., Sec'y-Treas. National District Heating Association Supt. of Jenkins Arcade Building, Pittsburgh		39	0.63

Chapter	Meeting Date	Subject	Speakers	Other Features	Attendance	Attendance Ratio*
St. Louis	Nov. 11	The Air Cooled Human Body	Dr. C.-E. A. Winslow, Yale School of Medicine, New Haven, Conn.	Refrigeration Section of Building Code was discussed	23	0.3
Southern California	Nov. 10	Penicillin (the new wonder drug)	A. J. Hess, Engr., English and Lauer, Inc., Los Angeles		55	0.64
Washington, D. C.	Nov. 17	Petroleum Has Gone to War	Walter Hochuli, Nat'l Dir. of Marketing, Petroleum Admin. for War	A film used to teach wartime boiler plant practice in England was shown	83	0.46
		Fuel Saboteurs	A. W. Thorson, Head Conversion Engr., Solid Fuels Admin.	A letter congratulating Society for its efforts in behalf of fuel conservation from Hon. Harold Ickes was read		
		Can Voluntary Conservation Save Fuel?	D. M. DeVard, Deputy Dir., Conservation Div. of WPB	Reports were submitted by the Chairmen of the Membership and Meetings Committees		
	Oct. 13	Accurate Shortcuts Induced by Expanded Naval Ventilation Requirements	Lt.-Comdr. E. R. Queer	Treasurer reported informally on Chapter finances	70	0.71
		Experiences and Activities Somewhere in the South Pacific	E. A. Tarwater, Warrant Officer, Sea-Bees	J. W. Markert was unanimously elected to Board of Governors		
Western Michigan	Nov. 8	Discussion on the ASHVE Guide	Prof. C. H. Pesterfield and A. H. Snook	President Pesterfield appointed committees on Air Cleaning Devices and on Automatic Controls	32	0.67
		Air Clean Devices				
		Automatic Controls	Prof. L. G. Miller			
	Oct. 11	Tales of Recent Experiences in Defense Plant Design.	S. R. Lewis, Consulting Engr., Chicago, Ill.	O. D. Marshall, W. W. Bradfield and Tom Stafford appointed on Fuel Conservation Committee to co-operate with Office of Civilian Defense	30	0.63
Wisconsin	Nov. 15	Sound Motion Picture on Plastics Industry — Application of Plastics	Supervised by William Black, Chief, Laboratory of Chicago Molded Products Corp.	Recent developments in connection with formation of Wisconsin Society of Professional Engineers	63	1.95
	Oct. 12	The Society's Activities in Wartime	Pres. M. F. Blankin, Philadelphia, Pa.		48	0.8
	Sept. 20	Combustion in Heating Boilers (coal-fired)	G. M. Hartman, Engrg. Dept., Kewanee Boiler Corp.		35	0.5

*The attendance ratios shown represent the meeting attendance divided by the Chapter membership. These will be useful as a partial indication of interest shown by local chapter members in various types of subjects programmed by other local chapters and may be helpful in deciding on subjects for other chapter meetings.

FUEL FIGHTS

In the December OPA Bulletin on Fuel Oil, it is pointed out that the following government agencies and committees cooperate in determining the supply and distribution of fuel oil to consumers under wartime conditions:

The Petroleum Administration for War is responsible for the production and distribution of all petroleum products to retail outlets where they are delivered to consumers. *A Petroleum Requirements Committee* of PAW, composed of representatives of all agencies involved in the production and distribution of petroleum products, including fuel oil, receives claims from the various war agencies as well as from the Army, Navy and Lend-Lease Administration. It weighs these claims and then allocates fuel oil to the military forces and to the war agencies, thus determining how much fuel oil the civilian population gets.

The Office of Civilian Requirements in WPB is responsible for determining the quantity of fuel oil necessary for civilian heating purposes. It also presents claims for all uses of kerosene except that which is consumed as tractor fuel. This agency presents its claims to the Petroleum Requirements Committee and the allocations are made by PAW to it and then transmitted to OPA, which rations this quantity for civilian consumption.

The War Production Board's Operations Vice Chairman presents estimates of the industrial requirements for fuel oil.

The War Food Administration presents the claims for tractor fuel.

The War Shipping Administration determines the quantity of fuel oil to be claimed for the bunkering of ships.

The Office of Defense Transportation determines the quantity of Diesel motor fuel to be claimed for use principally by the railroads and Diesel-powered motor tractors.

The Office of War Utilities presents the claims for the quantity needed for use by utilities.

The Petroleum Administration for War itself presents claims to the committee for the quantity of fuel oil necessary for refining operations.

The Office of Price Administration is responsible for allocating to civilians the quantity of fuel oil which is requested by the other agencies and determined by the Petroleum Administration for War.

A Petroleum Rationing Policy Committee, composed of representatives of OPA, WFA, PAW, OCR, ODT, and WPB advises OPA on rationing policies.

While the OPA is responsible for operating the rationing program itself, nine other Government agencies and committees are directly involved in determining the allocations for various war and civilian purposes and to various sections of the country.

While the fuel oil transportation shortage was the chief difficulty in the early months of the war, it is the fuel oil supply itself which is now dangerously short and has become the primary reason for fuel oil rationing.

Fuel oil rationing is complicated by the seasonal nature of consumption and variances in winter weather not only by sections of the country but from year to year. Since fuel oil is a product that is delivered to the home, the program takes into consideration the shortage of gasoline, tires, and delivery manpower.

The need of fuel oil conservation is more important than ever because of the dangerous supply situation, and every fuel oil user has the responsibility of making the fuel oil he gets do as efficient a heating job as possible.

An overall reduction of 30 per cent in fuel oil consumption for home heating purposes has been accomplished by the fuel oil rationing program.

D. J. LUTY RECEIVES PROMOTION

Donald J. Luty, a member of the ASHVE for over 10 years, has been appointed General Manager of the Heating Division, Gar Wood Industries, Inc., Detroit, Mich. Mr. Luty has been with the company for 14 years, and was Assistant General Manager of the Heating Division for many years. He also held the title of Chief Research Engineer.

ARMY-NAVY "E" TO BUENSOD-STACEY

The Army-Navy "E," for outstanding achievement in the production of heating, ventilating and air conditioning facilities, was awarded to the employees of Buensod-Stacey, Inc., New York, acting as sub-contractors to James Stewart & Co., Inc.

The award was made for the construction of the plant facilities of the Grumman Aircraft Engineering Corp., the builders of the famous Wild Cat and Hell Cat Fighters and the Avenger Torpedo Plane, which are held so highly in the esteem of our fighting men.

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FLYING OFFICER H. L. TEMPLE KILLED IN ACTION

Word has just been received from Major H. E. Temple that his son, Flying Officer Harold Luttrell Temple, R.A.F., a Junior Member of the ASHVE, lost his life on operations over enemy territory on August 10, 1943.

Officer Temple was born in London, England, on July 8, 1917. He

H. L. Temple

was educated at The Hall, Hampstead, England, and received his preliminary engineering training at Aundle, Northamptonshire, England, and later attended St. Andrews College, New Zealand, and the Borough Polytechnic Institute, London. At the latter he studied in the field of heating and ventilating.

In 1933 he entered the employ of Richard Crittall and Co., Ltd., London, as draftsman. He also worked on design, estimating and supervising of the heating, domestic hot water supply and ventilation installations, and prepared specifications. He remained in that position until 1938, when he became mechanical and electrical engineering assistant (heating and ventilating) in the Air Ministry, London. In this connection he designed and prepared specifications for district heating schemes on R.A.F. stations.

He supervised the design and installation on such buildings as St. Bartholomews' Medical School, London, in which was installed invisible panel warming and domestic

hot water supply, Heal's Premises, Plantation House, Birmingham Co-operative Society (stores), and various Royal Air Force Stations.

Among his friends and colleagues he was considered a brilliant technician and mathematician, and the Society has suffered a great loss. The Officers and Council of the Society extend their sincere and heartfelt sympathy to Major Temple and to his family for the loss of a very gallant Englishman.

J. E. SWENSON DEAD AT 52

The Officers and Council of the Society just received word of the death of John Edward Swenson, Minneapolis, Minn., who passed away suddenly on July 30, 1943, while vacationing in Browerville, Minn. Known to his many friends and associates as "Ed," Mr. Swenson was a past president of the Minnesota Chapter of the Society, a member of the Minnesota Engineers Club, and the *Mid-West Gas Association.*

Mr. Swenson was born on November 1, 1891, at Minneapolis and was an employee of the Minneapolis Gas Light Co. for 31 years. For the past 15 years he had been in charge of the house heating sales

J. E. Swenson

and prior to that time he was in the Service Division as shop foreman.

Mr. Swenson was Secretary-Treasurer of the Veterans' Club, a company group of 191 employees who had been with the company for 20 consecutive years. He also took great pride in being editor of the *News Letter,* a monthly publication sponsored by the Safety Committee and sent out regularly to 97 employees in the armed service in every corner of the globe.

Mr. Swenson had been a member of the ASHVE for over 13 years and took an active part in the Minnesota Chapter affairs. He will be missed by his numerous friends and associates in the profession.

The Officers and Council have sent an expression of sympathy to his family, his widow, Mrs. Matilda Swenson; a son, Ralph; and a daughter, Mrs. Dayton Amundson.

LIFE MEMBER J. J. RAINE DIES AT 74

Notification has just been received of the death of John J. Raine, Vice-President of G. S. Blodgett Co., Inc., Burlington, Vt. Mr. Raine, a Life Member of the

J. J. Raine

Society, passed away on April 23, 1943.

He was born on June 31, 1869, at Montreal, P. Q., and after leaving school he entered the employ of the G. S. Blodgett Co. as an apprentice in 1885 and spent his entire business career with the company.

He designed and superintended hundreds of installations in the New England States and in New York, including hotels, theaters, public institutions and industrial plants.

The Officers and Council of the Society regret the loss of a loyal and interested member.

A. R. KAMMAN DIES IN BUFFALO

Arnold R. Kamman, owner of the Arnold R. Kamman Co., Buffalo, N. Y., died on October 11, 1943, from complications following a major operation.

Mr. Kamman was born in Buffalo, on September 9, 1896, where he attended public school. He was graduated from Lafayette High School in Buffalo, and from the Rensselaer Polytechnic Institute in Troy. Following his graduation he spent one year with Buffalo Forge Co., leaving there to join the John W. Danforth Co., where he remained for 11 years. He was later employed by the Chippewa Plumbing Co., in whose employ he remained for over two years. In 1935 he opened a temperature control business of his own, which he maintained until his death.

Mr. Kamman joined the ASHVE in 1921, and will be missed by his many friends and colleagues in the heating and ventilating field. Besides being a member of the Society, he belonged to Theta Xi Fraternity, Air Conditioning Council of Western New York, Rochester Chamber of Commerce, and the Wanakah Country Club.

Mr. Kamman is survived by his wife, Mrs. Iva Persing Kamman; three sons, Arnold, Jr., Ronald and Jerry; one daughter, Nancy Carrol; and his father Charles H. Kamman; to whom the Officers and Council of the American Society of Heating and Ventilating Engineers extend their sincere sympathy.

WOODWORTH WETHERED, CONSULTING ENGINEER, DIES ON COAST

Woodworth Wethered, Consulting Engineer of San Francisco, died on November 19, 1943. He was born in Brooklyn, N. Y., on August 9, 1866. He served his apprenticeship in the Union Iron Works of San Francisco and then spent 10 years in construction work in the East and Middle West. For many years he was agent for the Paul Vacuum System of heating, and in 1901 he established a consulting engineering office in San Francisco, where he specialized in the design of mechanical equipment.

Mr. Wethered joined the Society in 1937 and he also held membership in the American Society of Mechanical Engineers.

He is survived by his nephew, Selim E. Woodworth of San Francisco, Calif., to whom the Officers and Council of the Society express their sincere sympathy.

Candidates for Membership

The Constitution of the Society, as now amended, requires the following mode of procedure in voting on applicants for membership in the Society. All applications for membership are to be sent to the Secretary and the names of applicants and their references shall be printed in the next issue of the Journal of the Society or sent to the members in other approved manner as ordered by the Council. When replies are received from references, the Candidate's application shall be submitted to and acted upon by the Committee on Admission and Advancement as soon as possible.

When the Committee on Admission and Advancement has acted favorably upon a Candidate's application and assigned his grade, the Council shall vote upon the election of the proposed Candidate for membership by letter ballot. During the past month 40 applications for membership have been received and the names of these men and their sponsors are published in the following list.

Members are requested to scrutinize the list with care. The Committee on Admission and Advancement, and in turn, the Council, urge members to assume their share of responsibility of receiving these candidates into membership by advising the Secretary promptly of any whose eligibility for membership is in any way questioned.

All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote.

Unless objection is made by some member by January 20, 1944, these candidates will be balloted upon by the Council. Those elected to membership will be notified by the Secretary immediately after election.

CANDIDATES	REFERENCES	
	Proposers	*Seconders*
AMMERMAN, A. S., Jr., Dist. Mgr., Aerofin Corp., Chicago, Ill. *(Advancement)*	E. P. Heckel S. R. Lewis	C. E. Price C. M. Burnam, Jr.
ANDERSON, CARL O., Htg.-Vtg. Engr., Board of Education, Chicago, Ill.	C. A. Gustafson A. J. Keating	J. F. Cummiskey L. Schulein
BECK, WALTER J., Br. Mgr., Minneapolis-Honeywell Regulator Co., Omaha, Nebr.	C. E. Wiser B. G. Peterson	E. F. Adams G. E. Merwin
BELYEA, ROY E., Mgr., Belyea Bros., Ltd., Toronto, Ont., Canada	W. C. Kelly H. R. Roth	D. O. Price A. J. Strain
BOYER, C. L., Owner, C. L. Boyer Plumbing, Heating & Industrial Piping, Dillon, Mont.	T. J. Sullivan E. K. Webster	A. N. McDonald J. C. Kelly
CHANDLER, ROY, Export Mgr., Wm. H. Wheeler & Co., New York, N. Y.	A. C. Buensod E. P. Heckel	H. L. Janet M. S. Smith
CLARK, L. O. RAY, Dist. Mgr., B. F. Sturtevant Co., Hartford, Conn.	P. D. Bemis J. R. Smak	M. F. Blankin L. A. Teasdale
COOKE, W. L., Managing Dir., W. L. Cooke, Ltd., Newmarket, Auckland, S. E. 1, New Zealand.	E. M. Taylor E. J. Gossett	*M. K. Draffin H. A. Lockhart
COOPER, GEORGE P., Combustion Engr., Empire-Hanna Coal Co., Ltd., Toronto, Ont., Canada.	A. J. Strain V. J. Jenkinson	W. C. Kelly H. S. Moore
COUCH, GEORGE R., Owner, Geo. R. Couch Co., Hartford, Conn.	P. D. Bemis G. F. Nieske	*J. H. Phelan J. R. Smak
DAVIS, CLARK M., Bldg. Equipment-Mech. Engr., Puget Sound Navy Yard, Bremerton, Wash.	L. L. Bysom *J. B. Hotkin	*L. J. Arthur *S. E. Rumcer
GAGE, BURFORD B., Owner, Gage Plumbing & Heating Co., Salina, Kans.	W. F. Ryan W. A. Russell	*L. J. Finn E. K. Campbell
GARBER, WILLIAM E., JR., Partner, Farquar Heating Service Co., Indianapolis, Ind. *(Advancement)*	C. L. Sapp V. G. Marconett	*J. T. Fraig H. E. Sproull
HAGUE, WILLIAM S., Mgr., Plumbing, Heating and Industrial Supplies, Crane Co., Indianapolis, Ind.	W. C. Bevington S. E. Fenstermaker	C. H. Hagedon G. B. Supple
HEATH, GEORGE A., Sales Engr., Mechanicsburg, Pa.	M. E. Barnard A. B. Snavely	W. D. Graham R. H. Smiles
HENDRIX, THOMAS K., N.T.S. Co. B. Sec. 4, Purdue University, Lafayette, Ind.	W. T. Miller C. F. Warner	L. W. Clark *H. G. Venemann
HOLLIS, RICHARD C., Sales Engr., Consolidated Conditioning Corp., Mt. Vernon, N. Y.	Thomas Baker H. J. Rose	Abraham Abrams J. A. M. Robertson
HUNT, JAMES F., Mech. Engr., Estimator, Designer, Cory & Joslin, Inc., San Francisco, Calif.	N. H. Peterson H. V. Hickman	K. O. Alexander R. B. Holland
JACK, ROBERT A., Adv. Salesman, Keeney Publishing Co., Chicago 2, Ill.	*A. L. Rybolt A. W. Williams	C. E. Price M. F. Blankin
LESTER, E. ARCHER, Asst. to Mgr., Crane Co., Indianapolis, Ind.	W. C. Bevington S. E. Fenstermaker	C. H. Hagedon G. B. Supple
MALLOY, WILLIAM W., Service & Application Engr., Ilg Electric Ventilating Co., Philadelphia, Pa.	F. D. Crew Ludwig Mack	H. H. Mather E. K. Wagner
MCGEARY, Mgr., Indiana District Office, The Trane Co., Indianapolis, Ind.	W. C. Bevington S. E. Goohs	T. R. Davis S. E. Fenstermaker
MCPHERSON, E. R., Dir. of Mfg. Facilities, Crosley Corp., Cincinnati, Ohio.	G. V. Sutfin E. W. McNamee	A. E. Edward Albert Buenger
MORROW, ALBERT P., Engr., Haynes-Blankin Corp., Philadelphia, Pa.	M. F. Blankin H. H. Erickson	A. E. Kriebel C. F. Dietz
MURRAY, WILLIAM A., Pres., William A. Murray, Inc., Hartford, Conn.	P. D. Bemis C. J. Lyons	*E. C. Inarsden T. M. Cunningham
NEVIN, CAPT. J. F., Chief Engr., Eastern Command Headquarters, India.	*J. T. Cathor *J. J. Dowling	
O'DONNELL, LAWRENCE D., Partner & Mgr., McCartny's Sheet Metal Works, Vincennes, Ind.	J. H. Niesse G. O. Jackson	S. E. Fenstermaker W. C. Bevington

PALMER, E. M., Mgr., Government Dept., Kewanee Boiler Corp., Kewanee, Ill.

PHILLIPS, M. C., Mgr., Air Cond. and Htg. Div., United Electric Service, Monroe, La.

PLATTS, EDMUND M., Vice-Pres., La-Del Conveyor & Manufacturing Co., New Philadelphia, Ohio.

PYSHER, MAURICE W., Sales Mgr., Standard Supply Co., Portland, Ore.

REED, A. G., Checker, Canadian Aircraft Instruments & Accessories, Ltd., Leaside, Ont., Canada.

ROLAND, JOHN, Chief Engr., Htg. Div., Schwitzer-Cummins Co., Indianapolis 7, Ind.

SIMON, JOSEPH P., Electrical Sales Engr., Cutler Hammer Co., Philadelphia, Pa.

SORMANE, WALTER, Sales Mgr., Schwitzer-Cummins Co., Indianapolis, Ind.

STROTHER, WILLIAM E., Capt., Corps of Engineers, Atlanta, Ga.

TREFTS, JOHN C., JR., Vice-Pres., Farrar & Trefts, Inc., Buffalo, N. Y.

URMSTON, BENJAMIN S., Dist. Engr., Airtemp Division of Chrysler Corp., Dayton, Ohio.

WEAVER, EUGENE A., Sales Mgr., Space Heating Division, Surface Combustion, Toledo, Ohio.

WHEELER, H. E., Pres., Air Comfort Corp., Chicago, Ill.

R. B. Dickson
C. E. Bronson
A. B. Banowsky
C. A. McKinney
T. H. Urdahl
E. R. Queer
E. C. Willey
L. J. Harrington
A. J. Strain
V. J. Jenkinson
C. W. Stewart
S. E. Fenstermaker
M. F. Blankin
H. H. Erickson
S. E. Fenstermaker
C. H. Hagedon
C. L. Templin
T. T. Tucker
B. C. Candee
M. C. Beman
I. C. Baker
W. H. Moler
W. M. Myler, Jr.
G. A. Linskie
H. J. Prebensen
K. C. Porter

J. M. Hartman
E. D. Quirke
R. B. Johnson
E. K. Campbell
R. A. Heindel
C. M. Hamblin
A. E. Finlay
B. W. Moore
W. C. Kelly
H. S. Moore
C. H. Hagedon
G. B. Supple
K. C. S. Jacobsen
C. F. Dietz
G. O. Jackson
W. C. Bevington
L. L. Barnes
I. B. Kagey
S. M. Quackenbush
H. C. Schafer
L. C. McClanahan
J. A. Ray
H. P. Morehouse
W. A. Catlett
S. R. Lewis
E. M. Mittendorff

*Non-member.

Candidates Elected

In the past issues of the Journal of the Society the names of the following men were listed as Candidates for Membership. The membership grade of each Candidate has been assigned by the Committee on Admission and Advancement and balloted upon by the Council. We are now instructed by the Council to post herewith, as required by Art. B-III, Sec. 8, of the By-Laws, the following list of candidates elected:

MEMBERS

ALEXANDER, HUGH V., Br. Mgr., Johnson Service Co., Indianapolis, Ind.

BARTON, FRED C., Supervisory Mech. Engr., Allison Engineering, Indianapolis, Ind.

CORYELL, GLYNN L., Chief Field Engr., U. S. Machine, Lebanon, Ind.

COTTON, IRWIN W., Owner, The I. W. Cotton Co., Indianapolis, Ind.

CULBERT, WILLIAM P., Partner, Culbert-Whitby Co., Philadelphia, Pa. *(Advancement)*

GALLMEIER, SIEGMUND H., Mech. Engr., Argonaut Realty Div., General Motors Corp., Detroit, Mich.

HALT, HOWARD R., Office Mgr., Thomas J. Sheehan Co., St. Louis, Mo. *(Advancement)*

HARDIN, JAMES T., Mgr., Htg. Dept., Roland M. Cotton Co., Indianapolis, Ind.

HATTERSLEY, EUGENE H., Member of Firm, A. Hattersley & Son, Ft. Wayne, Ind.

JORDAN, PAUL R., Pres., Paul R. Jordan & Co., Indianapolis, Ind.

LIMBACHER, HOWARD R., Research Engr., Ingersoll Steel & Disc Div., Borg-Warner Corp., Kalamazoo, Mich.

MAXWELL, LAWRENCE R., Sales Engr., Southern Heater Co., Inc., New Orleans, La.

MCDONALD, JOHN J., Owner-Mgr., The McDonald Co. & the John Van Range Co., Boston, Mass. *(Reinstatement)*

MORRISON, FRANK, Salesman, Hall-Neal Furnace Co., Indianapolis, Ind.

POST, GERALD A., Mech. Engr., F. H. Langsenkemp Co., Indianapolis, Ind.

SHILSTON, R. AYNSLEY, Htg. Engr. Asst., Manchester Corp., Manchester 2, England.

SHUTTLEWORTH, W. R., Design & Test Engr., Allison Div., General Motors Corp., Indianapolis, Ind.

STUART, RALPH A., Consulting Engr., Opera House Bldg., Terre Haute, Ind.

THORPE, WANO E., Estimator-Engr., J. J. Nolan & Co., Memphis, Tenn.

TYKLE, FREDERICK G., Plant Engr., Allison Div., General Motors Corp., Indianapolis, Ind.

WATTS, L. COPELAND, Partner, J. Roger Preston & Partners, London, W. C. 1, England.

ASSOCIATES

BARKER, M. S., Engr., Carrier Corp., Syracuse, N. Y.

BOONE, FRED S., Sec'y-Treas., Hall-Neal Furnace Co., Indianapolis, Ind.

BUSENLENER, LOUIS V., Mgr., Air Cond. Div., Higgins Industries, Inc., New Orleans, La.

FEITEL, J. YORK, Pres., Jordy Engineering Co., Inc., New Orleans, La.

GREAR, WALTER W., Engr., Freyn Bros., Inc., Indianapolis, Ind.

JOSLIN, GEORGE C., Sales Mgr., Tanner & Co., Indianapolis, Ind.

KEARN, JEFF, Mgr., Jeff Kearn Co., Windsor, Ont., Canada.

LEAS, NAT. N., Service & Installation Dept., Western Air and Refrigeration Co., Inc., Los Angeles, Calif.

MCGUINESS, C. H., Sales Engr., Carbon Coal Co., Des Moines, Ia.

NATHANSON, M., Engr., Gen. Mgr. & Owner, Canadian Armature Works, Montreal, Que., Canada.

NEWTON, ALBERT E., Engr., Hall-Neal Furnace Co., Indianapolis, Ind.

JUNIORS

FENSTERMAKER, S. E., Jr., Field Engr., American Blower Corp., Indianapolis, Ind.

HOYT, ROBERT A., Supt. & Furnace Installation, Hall-Neal Furnace Co., Indianapolis, Ind.

LASHLEY, WALTER L., JR., Gen. Foreman of Air Cond., Allison Div., General Motors Corp., Indianapolis, Ind.

REED, STANLEY F., Asst. Naval Architect & Htg.-Vtg. Engr., Kindlund & Drake, New York, N. Y.

SEIGEL, LAWRENCE J., Instructor, Case School of Applied Science, Cleveland, Ohio. *(Reinstatement)*

Officers

President.....M. F. BLANKIN
First Vice-President.....S. H. DOWNS
Second Vice-President.....C.-E. A. WINSLOW
Treasurer.....E. K. CAMPBELL
Secretary.....A. V. HUTCHINSON
Technical Secretary.....CARL H. FLINK

Council

M. F. BLANKIN, *Chairman* S. H. DOWNS, *Vice-Chairman*

Three Years: J. F. COLLINS, JR., JAMES HOLT, E. N. MCDONNELL, T. H. URDAHL.

Two Years: L. G. MILLER, A. J. OFFNER, A. E. STACEY, JR., B. M. WOODS.

One Year: E. O. EASTWOOD, A. P. KRATZ, W. A. RUSSELL, L. P. SAUNDERS.

Council Committees

Executive—E. O. Eastwood, *Chairman;* A. P. Kratz, E. N. McDonnell.

Finance—J. F. Collins, Jr., *Chairman;* C.-E. A. Winslow, B. M. Woods.

Membership—E. K. Campbell, *Chairman;* A. J. Offner, W. A. Russell.

Meetings—S. H. Downs, *Chairman;* James Holt.

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